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DOCTORAL DISSERTATION

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Abstract

This thesis is a collection of three empirical papers that tests hypotheses within the context of two related and intersecting theoretical frameworks: rational expectations and efficient markets. The aim is to empirically explore to what extent households form their inflation expectations in a rational manner, and to explain why households' perceptions may deviate from the measured official rate. This is done by studying how their expectations change with economic conditions and with information about their readiness to spend money on cars and houses. The thesis also addresses the effects of option introduction on the prices and risk of the underlying securities, where this information implicitly tests stock market efficiency.

Chapter 1 provides an overview of different concepts of expectations and describes the link between the hypotheses of rational expectations and efficient markets. The chapter also presents some stylised facts about the main dataset used to explore households' opinions about past and future inflation rates, and it provides a summary of each following chapter.

Chapter 2 explores to what extent households' inflation expectations are consistent with theories of rationality, and how these expectations change in times of major economic events and changes in the inflation environment. The events studied are the financial and economic crisis of 2008, several euro-cash changeovers, and periods of low and high inflation. The results show that households do not form rational expectations in the sense of Muth (1961).

Chapter 3 investigates whether households' purchasing plans for big expenditure items matter to households when they form their views on past and future inflation, and whether differences in their purchasing plans can explain the deviations usually found between surveyed inflation and the official measure of the rate of inflation. The results show that stronger incentives to collect information on inflation induce households to produce perceived and expected inflation rates that more closely correspond to the officially measured rate of inflation.

Chapter 4 investigates the effects of option introduction on the prices and risk of the underlying securities. The results show that the introduction of options provide the underlying stocks with a significant price increase, and a persistent excess return compared to an index indicating normal return. The impact on the total risk is also favourable, while no influence on the systematic risk could be verified. Volatility in the underlying stocks decrease continuously for ten months after the introduction of the option program.

Key words
Survey, inflation, expectations, perceptions, rational, inattentive, event study, option introduction, stock market, asset pricing, price effect, risk effect, derivative

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To Åsa, Ylva and Sten

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1 Introduction

This thesis is a collection of three empirical papers that tests hypotheses within the context of two related and intersecting theoretical frameworks: rational expectations and efficient markets.[1] The aim is to empirically explore to what extent households form their inflation expectations in a rational manner, and to explain why households' perceptions may deviate from the measured official rate. This is done by studying how their expectations change with economic conditions and with information about their readiness to spend money on cars and houses. The thesis also addresses the effects of option introduction on the prices and risk of the underlying securities, where this information implicitly tests stock market efficiency. This last topic formed the base for my licentiate degree, and was defended at a public hearing in September 2000.

1.1 Rational expectations, efficient markets and this thesis

A large part of economics is concerned with expectations. Expectations refer to the forecasts or views that decision makers hold about future key variables in their decision-making process. Consumers planning to smooth consumption over time form expectations about future income, prices, interest rates and taxes (Hall 1978). Producers deciding on future investments form expectations of future sales, costs and returns (Simon 1979). Policy makers aiming to stabilise the economy or inflation use forward looking fiscal and monetary policies to achieve their goals (Phillips 1958; Taylor 1979). As such,

[1] The information and views set out in this publication are those of the author and do not necessarily reflect the official opinion of the European Commission. The Commission does not guarantee the accuracy of the data included in this study. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.

expectations are a basic building block of economic theories, and economists try to measure them, analyse their effects on the economy, and study how they are formed.

The assumption of rational expectations is still the standard methodology for modelling expectations (Evans and Honkapohja 2001). Although there are more recent expectation theories, rational expectations is still a rather recent step in a long line of theory development that emphasises the importance of expectations.

The most simple assumption about expectations one can make is that of naïve or static expectations, which was used in the early literature. It implies that the current value of an economic variable is the best prediction of the value in the following period, and the notion of static expectations is credited to Alfred Marshall (see, e.g., Grossman 1981; Evans and Honkapohja 2001). One of the most well-known formal models incorporating static expectations was the 'cobweb theorem' in agriculture. This model describes how cyclical demand and supply in a market can give rise to price fluctuations when producers have to decide on the amount to produce before they can observe the prices (Kaldor 1934; Pashigian 2008).

Adaptive expectations generalises the idea behind static expectations, postulating that economic agents take into account not just the current value of an economic variable, but a weighted average of past observations of the variable. It played an important role in modelling inflation expectations in monetary economics. Adaptive expectations was formally introduced by Cagan (1956), Nerlove (1958) and Friedman (1968), when studying hyperinflation, farmers' planting decisions, and the role of monetary policy, respectively.

Later research showed that these models were not sufficiently robust given their assumptions on how expectations were formed, as the results of both theoretical and empirical work depended on the specification of the expectations. In certain contexts, other forecasting rules could improve the forecasts, where the optimal forecast method proved to be contingent on the stochastic process of the variable being forecasted, i.e. there was an interdependence between the forecasting method and the economic model.

John Muth (1961) recognised this problem and suggested that expectations might change in the course of events, and should therefore not be specified in a way that does not allow them to change. If the economic system changes, people should also change the way they form their expectations, at least eventually. Furthermore, Muth suggested that economic agents in models

should act consistent with the models used to explain their behaviour. This would ensure that the behaviour of the model was consistent with the economic agents' beliefs about the economic system they act within (Sheffrin 1996). He called such expectations rational.

Rational expectations is an equilibrium concept (Sargent 2008), where expectations are model consistent. Economic agents within the model are assumed to know the model and take the model's predictions as valid. The assumption is that forecasts done within the model does not differ systematically from the market equilibrium of the model, i.e. economic agents do not make systematic errors when forecasting the future value of different variables, and any deviations are random. Given the information available, this is modelled by assuming that the expected value of an economic variable is equal to the expected value predicted by the model.

Following the 'rational expectation revolution', a lot of research has been done concerning the bounds of rationality within the field of behavioural economics. Behavioural theories and models integrate insights from psychology, neuroscience, and microeconomics. The idea is that when people make decisions they are subject to cognitive limitations (or bounded rationality), self-control problems, and social preferences. For surveys of behavioural economics, see e.g. Dellavigna (2009), Camerer (2014), and Thaler (2015).

The following two chapters should be placed in the intersection between these last two concepts, i.e. to what extent households form rational expectations or are rationally inattentive. Inattention follows from the constraints on rationality that households face, e.g. from insufficient processing capacity, lack of time, or other frictions that prevent households from forming expectations in line with rationality as prescribed by theory. The first chapter tests hypotheses implied by rational expectations and rational inattention, and the second distinguishes between different types of households to see if inattention differs depending on their intention to buy cars, houses or making home improvements.

The final chapter is connected to the second and third chapter via the close relationship between rational expectations and the efficient market hypothesis, which is a benchmark approach in financial economics. The efficient market hypothesis is usually attributed to Samuelson (1965) and Fama (1965). The two concepts of rational expectations and the efficient market hypothesis are often associated with each other (see, e.g., Mishkin 2016), as both are equilibrium concepts. The efficient market hypothesis postulates that asset prices reflect all available information, while rational expectations similarly

imply that prices reflect the best or optimal forecast of the assets' future return. The two concepts are even claimed to be equivalent, but their respective development is better characterised as independent from each other (Delcey and Sergi 2019).

The last chapter examines the effects of option introductions on the price and risk of the underlying assets. Black and Scholes (1973) assumed that options are redundant assets and could thereby derive a pricing rule for derivative securities. However, researchers recognise that financial markets are not complete, which imply that introducing derivatives could make markets more efficient, lead to welfare effects and make derivative markets interact with the underlying securities market (see, e.g., Ross 1976, Hakansson 1982, and Detemple and Selden 1991). By empirically testing hypotheses related to redundancy of derivative securities and the information content of option introductions, Chapter 4 is also related to the other two chapters, by providing implicit tests and evidence of the efficient market hypothesis.

1.2 Survey data and rational expectations

Instead of resorting to theoretical arguments to determine the best way to build an economic model based on expectations, a researcher can empirically examine the available data on households', firms' or experts' expectations. Today there are several surveys that provide data on expectations. These surveys cover several aspects of economic development, including forecasts for inflation, commodity prices, interest rates, and foreign-exchange rates.

Among the earliest and most used datasets are the Livingston data on inflation expectations; other examples include the Blue Chip Economic Indicator Survey, Commerce Department data, and Money Market Services. These datasets have been developed in the US. To mention two tests of rationality, Pessando (1975) was the first researcher to test for rationality using the Livingston data. He rejected the rationality hypothesis because the forecasts of inflation at different times in the future were not consistent with one another. Using the Blue Chip Economic Indicator Survey, Batchelor and Dua (1991) showed that individual interest-rate forecasts were rational in the sense that forecasts were unbiased and that the forecast error was uncorrelated with small information sets known at the time when the forecasts were made. However, the frequency of rational forecasts declined significantly when more information was used in the tests.

Today there are many survey-based datasets on expectations covering households and firms in several countries outside the US and on different continents. Some are qualitative surveys (non-numerical categorical data) and others are quantitative (numerical data). The focus of this thesis is on quantitative measures of households' inflation expectations, and there are several examples of such surveys. Among the earlier datasets are the Swedish Household Survey (see, e.g., Jonung 1981), the University of Michigan Survey of Consumer Attitudes (see, e.g., Curtin 2010), and the Inflation Psychology Survey conducted by the Federal Reserve Bank of Cleveland in association with Ohio State University (see, e.g., Bryan and Venkatu 2001). Surveys in other countries, such as Australia (see, e.g., Ballantyne 2016), New Zealand (see, e.g., Ranchhod 2003) and South Africa (Kershoff 2000), also include explicit questions on inflation in their respective consumer surveys. More recently, surveys of consumers' quantitative inflation expectations have been launched in Brazil (Campelo et al. 2014), Canada (Bank of Canada 2015), and India (Das et al. 2018).

This thesis makes use of a unique and relatively unexplored dataset compiled by the European Commission. In May 2003, the European Commission, in association with its partners, introduced two new questions into the Harmonised Consumer Survey for the European Union (see European Commission 2016), thereby substantially adding to the number of surveys that explicitly ask a selection of respondents (representing the public at large) about their inflation perceptions and expectations. The data from these surveys are particularly suitable for studying the formation of perceptions and expectations of inflation, as the methodology applied across the then 28 EU member states is consistent, while providing a variety of country specific conditions and differences. For a more complete description of the data see European Commission (2006).

The harmonised questionnaire contains two questions asking respondents to put a number on the inflation rate that they perceived to be over the past 12 months and what they expect it to be for the following 12 months. It also contains information on income, occupation, work regime, education, age, and sex.

Table 1 provides some descriptive statistics of the whole dataset between January 2004 and May 2014, where the descriptive statistics for the monthly survey results are aggregated across time by calculating simple averages. The two last rows in the table show the total number of responses to the surveys. For the 125 months considered, a total of 4 340 982 individuals responded to the national surveys. Out of these, 73% gave a quantitative estimate of their

past and future opinion on inflation. On average, households perceived the inflation rate to be almost 11% and expected inflation to be 8.5%. The table also shows the wide range of possible replies that households provided as estimates for average annual inflation. Perceived inflation ranges from 900% down to -400% and expected inflation ranges from 900% to -500%. The 75th and 25th percentile show that more than 50% of the answers for perceived inflation lay between 2.0% and 15.0% and between 0.0% and 10.0% for expected inflation.

Table 1: Descriptive statistics on households' perceived and expected inflation rates
Distribution of households' quantitative estimates of perceived and expected inflation, Jan 2004 to May 2014. In all calculations, an equal weight is applied to all responses.

STATISTIC	PERCEIVED INFLATION	EXPECTED INFLATION
Mean (%)	10.9	8.5
25th percentile (%)	2.0	0.0
Median (%)	5.0	5.0
75th percentile (%)	15.0	10.0
Max (%)	900.0	900.0
Min (%)	-400.0	-500.0
Mode (%)	0.0	0.0
Relative frequency of mode (%)	18.4	27.2
Standard deviation	15.5	13.7
Skewness	4.3	4.9
Kurtosis	80.8	99.1
Total number of respondents	4 340 982	4 340 982
No. responding to quantitative questions	3 264 361	3 183 807

The median responses to the two quantitative price questions were both 5%. As the means were substantially higher (10.9% and 8.5%), this suggests that they are heavily influenced by outliers. It is clear from the table that households overstated both perceived and expected inflation, where perceptions were far from the official inflation rate based on the Harmonised Index of Consumer Prices (HICP). To some extent this reflects a de-linkage between perceived and the official HICP rate of inflation that occurred when the euro notes and coins were introduced in January 2002. Whether this de-linkage happened because of a loss of 'price memory', higher prices for frequently purchased items, or psychological effects, it is nevertheless likely that it takes a long time before perceptions and expectations align with each other and the official rate of inflation (see, e.g., Ehrmann 2006, Marques and Dehaene 2004, and Fischer et al. 2002).

Chart 1: Histogram of households' perceived and expected inflation
Relative frequency of replies in 27 EU member states, Jan 2004 to May 2014

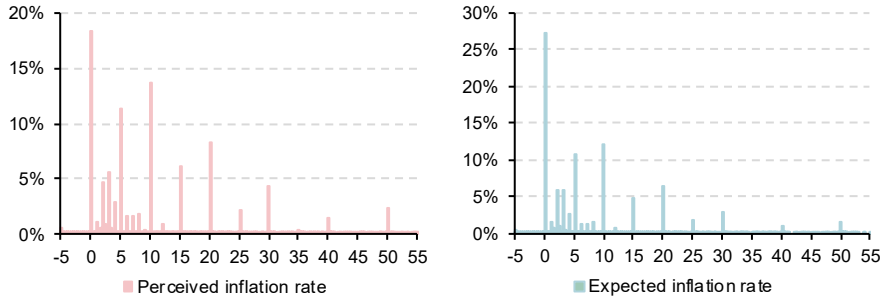
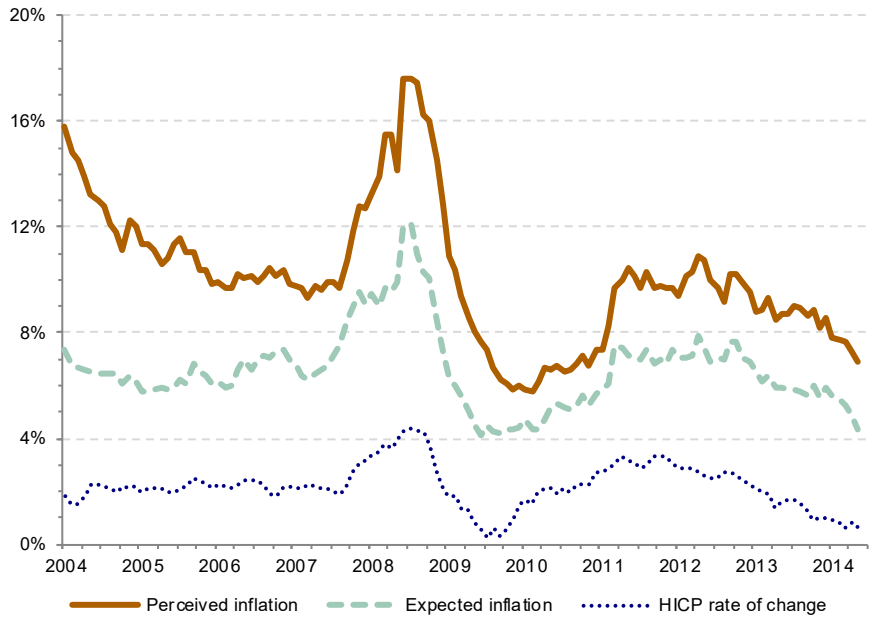


Chart 2: Households' perceived and expected rate of inflation and the EU HICP inflation rate
Weighted average of perceived and expected inflation in 27 EU member states. Perceived and expected inflation are calculated using equal weigths for individual responses, HICP country weights, and adjusted for differences in monthly sample sizes.



Although the ranges of numbers reported by respondents are very wide, the mode of the two distributions, i.e. the inflation rates reported with the highest frequencies, were both 0. Besides 0, with a relative frequency of 18% for perceptions, the most preferred numbers were 10, 5, and 20 with frequencies

ranging from 14-8%. For expectations, the most preferred numbers after 0 (with a relative frequency of 27%) were also 10, 5, and 20 with frequencies ranging from 12-7%. Other popular numbers were 2 and 3, and other multiples of the number 5. The distributions also exhibit a high degree of variation as depicted in Chart 1 and by the standard deviation shown in Table 1. Furthermore, the distributions deviate from normality by being skewed to the right and having fat tails. This is in line with earlier evidence from Carlson (1975), Batchelor (1981, 1982), and Lahiri and Teigland (1987).

Chart 2 shows the time series for both perceived and expected inflation. The dotted line at the bottom of the figure is the official HICP rate of inflation. The other two lines are households' perceived (continuous line) and expected (dashed line) inflation rates.

In general, the chart shows that both perceived and expected inflation are much higher than the official rate, and that perceived inflation is much higher than expected future inflation. Furthermore, perceived inflation was trending downward since the beginning of January 2004 until 2007, when the first signs of the financial crisis emerged. The very high perceived inflation rate is probably linked to the cash changeover that occurred in January 2002, and the decline shows the adjustment process of perceptions. Longer time series of qualitative data show a similar pattern (see European Commission 2006). Households' inflation expectations have followed the movements of the HICP inflation rate more closely. The correlation coefficients between the HICP rate of inflation and households' perceived and expected inflation are 63% and 82%, respectively.

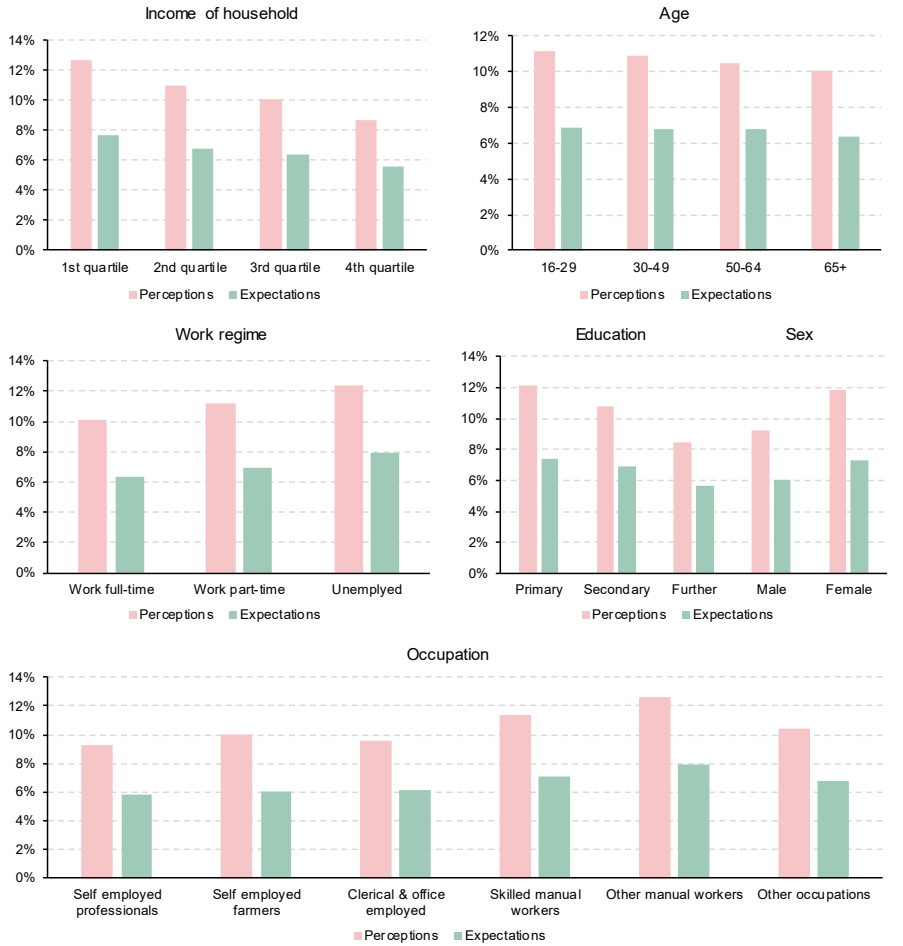
Respondents to the Harmonised Consumer Survey for the European Union can be categorised by the answers to five questions of a socioeconomic nature: income of the household (4 classes), age (4 groups), work regime (3 categories) occupation (6 categories), education (3 levels), and sex (male or female). Chart 3 shows how the answers are distributed depending on socioeconomic belonging.

Several disparities emerge across the different socioeconomic groupings. Perceived and expected inflation fall as income rises. Perceptions fall by as much as 4.0 percentage points (p.p.) from the first quartile (25%-lowest income earners) to the fourth quartile (25%-highest income earners). The difference for expected inflation is 2.1 p.p. Similarly, reported inflation rates fall as respondents' education increases. The difference between households with primary schooling and those with an education that goes beyond secondary schooling is 3.6 p.p. for perceptions and 1.7 p.p. for expectations.

This finding is consistent with the fact that, in general, households with higher education have higher incomes. Sex also matters; women perceive and expect higher inflation rates than men. The differences are 2.6 p.p. and 1.3 p.p. for perceptions and expectations, respectively. Finally, younger households perceive and expect slightly higher inflation rates than older households. However, the differences are less pronounced than for the other categories.

Chart 3: Households' perceived and expected inflation across socio-economic groups

Weighted averages of perceived and expected inflation in 27 EU member states. Perceived and expected inflation are calculated using equal weigths for individual responses, HICP country weights, and adjusted for differences in monthly sample sizes.



1.3 Chapter overview

The thesis is composed of three chapters, with two different focuses: inflation expectations and asset pricing. The differences in focus and topics reflect the rather long gap between my first and second period of academic studies. I started this thesis as a PhD student at Stockholm School of Economics in the Department of Finance, more than 25 years ago, and finished it at Lund University, where I started my academic studies as an undergraduate student. Chapters 2 and 3 concern households' inflation expectations, where Chapter 2 tests to what extent households responding to the surveys form rational expectations as defined by different theories of rationality, and Chapter 3 proposes an explanation as to why surveyed inflation perceptions deviate from the official measure of inflation. Chapter 4, which formed the base of my licentiate degree, deals with pricing effects on stocks of option introductions.

1.3.1 Do exceptional events and the inflation environment impact the rationality of inflation expectations?

The second chapter explores to what extent households' inflation expectations are consistent with theories of rationality, and how these expectations change in times of major economic events and changes in the inflation environment. The events studied are the financial and economic crisis of 2008, several euro-cash changeovers, and periods of low and high inflation.

The hypothesis is that people become more informed during major events and at times of high inflation. This reduces their forecasting error and produces expectations that are more consistent with theories of rationality. To this end, the chapter makes use of a unique database that covers more than 3 million observations of households' inflation expectations from 27 out of the then 28 member states of the European Union. The dataset has been developed within the framework of the Joint Harmonised EU Programme of Consumer Surveys, which is managed by the European Commission. The questionnaire contains a question explicitly asking households to quantify the future rate of inflation.

The results show that households do not form rational expectations in the sense of Muth (1961), and that their rationality does not improve in times of crisis or at the time of a major economic event such as changing the domestic currency to the euro. The results suggest that households use a rather constant amount of resources and effort in forming expectations on inflation, except possibly in extreme situations when one-off changes to expectations are formed. In times

of economic crisis, the expectation bias increases; when inflation is low, the bias decreases. These results are consistent with households that spend a fixed amount of resources and effort on forming expectations, which implies that occasionally they perform better relative to the official inflation rate, and at other times worse. For example, when inflation is low, inflation variability is low, which makes it easier to form expectations. On the other hand, during times of crisis, volatility is high, as is uncertainty, which makes it more difficult to form expectations. A new situation may also require people to adjust their thinking (their model) which, if not done, leads to a larger expectation bias.

There is only weak empirical support in favour of the theory of rational inattention. When a crisis turns sufficiently extreme, as during the sovereign debt crisis in 2012, the cost of not updating one's information set and thinking seems to become too high. In this situation, people are compelled to update and produce less biased expectations relative to households experiencing more moderate crises. Nevertheless, the biases increase regardless of the severity of crisis. Introducing the euro may also be classified as an extreme event, but in this case the biases in inflation expectations decline. However, this decline is a one-off adjustment of the level of inflation expectations.

1.3.2 Why do households' perceptions and expectations of inflation differ from the official measure of inflation?

The third chapter investigates whether households' purchasing plans for big expenditure items matter to households when they form their views on past and future inflation, and whether differences in their purchasing plans can explain the deviations usually found between surveyed inflation and the official measure of the rate of inflation. The hypothesis is that the more likely households are to spend a large sum of money, the stronger incentive they have to collect and process data to forecast inflation; this leads to households producing better inflation projections.

The empirical analysis makes use of the same dataset as in Chapter 2. Besides the two questions explicitly asking households to quantify the past and future rate of inflation, the surveys include three questions on households' likelihood to buy a car, a house, and spend a large amount of money on home improvements. These three questions are used as a device to group households in terms of the strength of incentives they may have to collect information on inflation.

The results show that stronger incentives to collect information on inflation induce households to produce perceived and expected inflation rates that more closely correspond to the officially measured rate of inflation. After correcting for outliers, households that say they are likely to spend a large sum of money on a car, a house, or home improvements both perceive and expect the inflation rate to be lower than those not likely to spend a large sum of money. Furthermore, at times of high inflation, a substantial part of the difference between households' opinions about the inflation rate and the official rate can be explained by these spending plans, which is consistent with the theory of rational inattention. However, it is not sufficient to explain the whole difference. A significant bias remains, especially for perceived inflation, which leaves room for other explanations not tested in this thesis.

1.3.3 The price and risk effects of option introductions on the Nordic markets

The opening of the Chicago Board Options Exchange (CBOE) in 1973 started a new era of derivative trading. CBOE revolutionised the option trading by creating standardised, listed stock options. In the same year Black and Scholes (1973) published their work on option pricing. They assumed that options are redundant assets and could thereby derive a pricing rule for derivative securities. This was done by applying a so called no-arbitrage argument and by constructing a dynamic hedge portfolio. Since then academics have questioned the assumption of redundancy. Researchers recognise that financial markets are not complete. Therefore, introducing derivative securities could increase the opportunity set of investors, which in turn could make markets more efficient, lead to positive welfare effects, and make the derivatives market interact with the underlying securities market.

The final chapter empirically investigates the effects of option introduction on the prices and risk of the underlying securities. The data used come from the stock markets in Denmark, Finland, Norway, and Sweden as well as from the option market in Sweden. The study is motivated fourfold:

1. One reason is to check the results and implications of theories regarding option introduction presented in the academic literature.
2. Most studies concerning the impact of option listing on the underlying stock have been based on data from the US. To confirm the results from these studies, evidence from other data sets are needed.

3. Studies based on US data have found time-varying price and risk effects. These results, which diverge from most other findings, are compared with those results based on data from the Nordic markets.

4. Policy questions arise on account of concerns that derivative trading adds to the instability of the underlying assets market. Such trading often gets blamed for increased instability. Some solutions to reduce instability have been proposed, such as introducing frictions into the market that would reduce the speed of transactions, e.g. the introductions of a turnover tax on short-term positions. Although no explicit conclusions can be drawn, it is worthwhile checking if the allegation of adding instability has any empirical support.

There are several arguments suggesting that there exist effects on the underlying stock returns related to the listing of options. The structure, magnitude or even the direction of these effects are debatable, and a better understanding of the effects involved can only be determined empirically.

In the Nordic countries, the introduction of options has proved to provide the underlying stocks with a significant price increase, and a persistent excess return compared to an index indicating normal return. The positive effect is strong and similar in magnitude to those in studies based on data from other countries. Contrary to the experiences from other studies, the observed increase in returns seems to be associated with the date of announcement of the option program, rather than the date of introduction. Further, there is no evidence of a trend in the size of the price effect, as found in recent work based on option introductions made in the US. The findings in this study are therefore in harmony with the market efficiency hypothesis and the expectations that prices should be promptly adjusted when additional information reaches market participants.

The positive price effect could be explained by a change in the risk of the underlying stock. An increased systematic risk or an increased idiosyncratic risk can lead to a price increase, assuming that the capital asset pricing model holds. As the results show, no statistically significant support can be found for this argument. It can also be argued that options expand the opportunity set of investors and promote risk reallocation, which can be beneficial to market participants. To the degree that the investors experience a better control of the financial risk when options are introduced, the required yield can be reduced.

The impact on the total risk is also favourable, and in line with findings in other studies. No influence on the systematic risk could be verified. Volatility in the underlying stocks is found to decrease continuously for ten months after the

introduction of the option program. Furthermore, there is no evidence of a trend in the size of the volatility effect, as found in recent US studies. These results support the notions that derivatives widen the investment choices of market participants, decrease risks, and provide improved hedging opportunities.

In all, this study supports the idea that option introductions make markets more efficient. The results of the analysis do not provide any indication that derivative trading contributes to financial unrest. On the contrary, option programs seem to add increased stability to the market.

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2 Do exceptional events impact the rationality of inflation expectations?

2.1 Introduction

This chapter explores to what extent households' inflation expectations are consistent with theories of rationality, and how this consistency changes in times of major economic events and with the inflation environment. The events studied are the financial and economic crisis of 2008 and several euro-cash changeovers. The hypothesis is that people become more informed during major events and at times of high inflation, which reduces their forecasting error and produces expectations that are more consistent with theories of rationality. To this end, the chapter makes use of a unique database on households' inflation expectations.

With the failures of models assuming full-information and rational expectations, there has been a renewed interest in resolving the problems by focusing on better understanding the frictions and limitations people face in the acquisition and processing of information (Coibion and Gorodnichenko 2012). For example, the delayed and differential response of inflation to monetary policy and technology shocks is not easily generated without adding information rigidities (Mankiw and Reis 2002; Dupor et al. 2009).

In this context, the theory of rational inattention is motivated by the idea that individual people are constrained in their ability and capacity for processing information, and therefore form their expectations based on incomplete information (Sims 2003). However, the theory also suggests that people shift more attention to the process of forming expectations when it becomes important to do so (Reis 2006a). These theories are part of the grander field of behavioural economics (see, e.g., Golman et al. 2017; Thaler 2015), and have implications for how, for example, macroeconomic models are augmented

with frictions and fitted using inflation expectations data (see, e.g., Ormeño and Molnár 2015).

Testing for different forms of weak and strong rationality is a longstanding topic in economic research (see, e.g., Carlson and Parkin 1975; Jonung and Laidler 1988; Dias et al. 2010), and more recently also involves the theory of rational inattention.[2] For example, Lanne et al. (2009) show that a significant proportion of the population rely on the past release of actual inflation data, instead of basing their expectations on rational forward-looking forecasts produced by professional forecasters. Easaw and Golinelli (2012) distinguish between purely forward-looking and 'stubborn' households, i.e. those that rely on their lagged one-year-ahead forecast. Easaw et al. (2013) employ an error-correction model to show that: (i) households absorb professional forecasts when forming expectations; (ii) households' expectations are determined by current inflation (or perceptions of current inflation); and (iii) current inflation signals are used to determine the future direction of inflation rates. Following the approach of Easaw et al. (2013), Campelo et al. (2014) studied the formation of inflation expectations in Brazil, adding the effects of households' opinions on the personal and general economic situation.

This chapter adds to this research by studying households' rationality and to see how it changes with major economic events and the inflation environment. Using a unique dataset, covering more than 3 million observations of households' inflation expectations from 27 member states of the European Union (EU), the chapter presents the results of conventional tests of attitudes under the hypothesis that respondents form rational expectations (see, e.g., Jonung and Laidler 1988; Ekeblom 2014). Furthermore, it adds to previous research testing the theory of rational inattention by exploring how the results of the conventional tests change in response to the financial crisis that started in 2007 and later developed into a debt and currency crisis in the euro area. This was the most severe crisis since the Great Depression in the 1930s. The idea tested is that the risk of incurring costs would induce households to follow the evolving events, update their information and expectations, and react

[2] The rational expectations hypothesis, first introduced by Muth (1961), states that expectations of an economic variable are based on all available information, including historical values of the variable as well as current knowledge about its future values. Tests of rational expectations are usually classified in terms of weak-form and strong-form tests, imposing different assumptions on the information set that people use when forming their expectations. Weak-form tests basically examine if a forecast of a variable is unbiased, or if past values of the variable can be used to explain any error between the forecast and the realised variable. Strong-form tests examine whether any other information can explain the forecast errors.

accordingly to maximise their utility. During the sample period, several countries also abandoned their national currency when joining the euro area; as well, measured inflation fluctuated more than in a long time. Both euro cash changeovers and changes in the inflation environment have possible implications for households' expectation formation. A final novelty concerns the information set used to test rational expectations, which distinguishes between traditional macroeconomic data (e.g. unemployment and interest rates) and more personal, or micro-oriented data, such as the economic situation of a given household.

The results show that households do not form rational expectations in the sense of Muth (1961), and that their rationality does not improve in times of crisis or at the time of a major economic event such as changing the domestic currency to the euro. The results suggest that households use a rather constant amount of resources and effort in forming expectations on inflation, except possibly in extreme situations when one-off changes to expectations are formed. In times of economic crisis, the expectation bias increases; when inflation is low, the bias decreases. These results are consistent with households that spend a fixed amount of resources and effort on forming expectations, which implies that occasionally they perform better relative to the official inflation rate, and at other times worse. For example, when inflation is low, inflation variability is low, which makes it easier to form expectations. On the other hand, at times of crisis volatility is high, as is uncertainty, which makes it more difficult to form expectations. A new situation may also require people to adjust their thinking (their model) which, if not done, leads to a larger expectation bias.

There is only weak empirical support in favour of the theory of rational inattention. When a crisis turns sufficiently extreme, as during the sovereign debt crisis in 2012, the cost of not updating one's information set and thinking seems to become too high. In this situation, people are induced to update and produce less biased expectations relative to households experiencing more moderate crises. Nevertheless, the biases increase regardless of the severity of crisis. Introducing the euro may also be classified as an extreme event, but in this case the biases in inflation expectations decline. However, this decline is a one-off adjustment of the level of inflation expectations.

2.2 Theory and hypotheses

The basic idea behind rational expectations is that people use all available information efficiently to form expectations about the future without making systematic errors in their predictions (Muth 1961). However, if people have limited capacity to process costly information, they may form their expectations based on incomplete data. This may lead to systematically biased forecast errors, which may vary in size depending on economic circumstances. As discussed by Sims (2003), if people have limited capacity for processing data, the amount of effort devoted to collecting information and forming expectations may vary with the benefit of having more complete datasets and better forecasts. By using information theory, Sims developed a model where the information flow about macroeconomic variables is very low, and where people only devote a fraction of their information-processing capacity and attention to macroeconomic variables. A complementary approach is offered by Reis (2006a, 2006b), who assumes that it is costly for people to acquire, absorb, and process information in forming expectations and making decisions.[3] In this setting, people rationally choose to update their information and their plans infrequently. Information becomes 'sticky' and gradually dissipates to the population over time. The model describes a rational behaviour by agents where they update information infrequently, as the optimal response to explicitly modelled costs of planning. These two strands of theories of rational expectations have several testable implications. A financial crisis provides the right setting for testing such implications, as both the cost of being complacent and the information flow on economic performance increase during a crisis.

Rational expectations put constraints on how individuals' expectations relate to the variable being predicted and on how individuals use information to form their expectations. There is a longstanding literature on testable implications, where four are commonly tested (see, e.g., Sheffrin 1996). These tests can be categorised as tests of unbiasedness, efficiency, forecast-error unpredictability, and consistency. For unbiasedness to hold, agents' expectations should not systematically deviate from the outcome. This is a test of the weak-form version of rational expectations, which is independent of the agents' information set. For efficient expectations to hold, past information on

[3] The two approaches complement each other, as Sims (2013) focuses on the information problem facing agents, while simplifying their actions. Reis (2006a), on the other hand, focuses on the decisions of agents and their interaction with inattentiveness, while simplifying the information acquisition problem.

inflation should not improve the agents' forecasts. For forecast-error unpredictability to hold, no other information should help to improve the agents' forecasts. This test places restrictions on the information set of agents, which is a test of the strong-form version of rational expectations. Finally, for consistency to hold, forecasts made for different times in the future should be consistent with each other. To a large extent these tests are similar in the sense that they all test different properties of conditional expectations.

2.2.1 Weak and strong rationality hypotheses

This chapter investigates whether households form weak- and strong-forms of rational expectations, as introduced by Muth (1961), and combines the tests for unbiasedness and forecast-error unpredictability (see, e.g., Sheffrin 1996). The first two hypothesises investigated — Hypothesis 1 (H1) and Hypothesis 2 (H2) — are the following:

H1: Households form unbiased predictions of inflation 12 months ahead — weak rationality.

H2: Households' expectations are uncorrelated with any information available at the time the forecast is made — strong rationality.

A rejection of the first hypothesis would imply that agents make systematic errors when forming their expectations of future inflation. However, there are no implications for the directions of the bias. For example, if agents use adaptive expectations and inflation is on an upward trend, the bias will be negative, as expected inflation is consistently lower than the true inflation rate. If inflation is trending downward, the opposite is true: expectations will be higher than the true inflation rate.

A rejection of the second hypothesis would imply that households exclude taking certain information into account when forming their expectations, and that their forecast can be improved by doing so. Including both macroeconomic variables (e.g. unemployment and interest rates) and private information (e.g. the household's own financial situation) in the tested information set allows for distinguishing between information that is available but inaccessible, as opposed to information that is privately known and accessible to the household. This puts different restrictions on the information set used to form expectations and makes it possible to distinguish between degrees in the strength of rationality. In both cases, however, there are no implications for the direction of the correlation of the information. Correlation could be negative

or positive; either way, it would be a rejection of the strong-form of rational expectations.

2.2.2 Rational inattention hypotheses

There are several indications that inflation expectations formed by surveyed households in the EU violate the conditions for rational expectations (see, e.g., Lindén 2010; Arioli et al. 2016). Instead the theory of rational inattention provides another set of testable predictions, which allows for frictions in the expectation-formation process. The following list of predictions is not exhaustive, but they are the most relevant for the purpose of this chapter. First, households respond more quickly to news that refers to some extraordinary event that captures everyone's attention. Second, the higher the risk faced by a household and the higher aversion to this risk, the higher are the costs of being inattentive. Thus, the household will be inattentive for a shorter period of time when the risk increases. Third, the lower the inflation rate, the higher the inattentiveness. In recent years, the European Union has experienced several events and fluctuating inflation that affect households in line with these predictions, which provide a suitable environment for testing both rational inattention and rationality in the sense of Muth (1961).

The hypothesis concerning rational inattentive households can be grouped into three categories defined by the evolution of the financial crisis that broke out in 2007 and by the euro-area developments: (i) the financial and the economic crisis, exploiting different time periods (with or without crisis); (ii) extraordinary events, differentiating member states based on how severe the crisis was for each individual country and whether a member state introduced the euro; and (iii) the inflation environment, i.e. periods of low or high inflation. Thus, the following additional four hypotheses can be grouped accordingly: (i) Hypothesis 3 (H3); (ii) Hypothesis 4 (H4) and Hypothesis 5 (H5); and (iii) Hypothesis 6 (H6):

The effect of economic crises on rationality

Hypothesis 3 tests the implication that households update their expectations when they face a situation that significantly changes economic conditions:

H3: Households become more rational during a crisis period.

By 'more rational' is meant that households form expectations that are more in line with Hypotheses 1 and 2, i.e. any systematic bias is reduced and any

correlated information becomes less correlated. However, it does not imply that households are fully rational.

The financial crisis and the following currency and debt crises changed the economic conditions, with lower growth, higher unemployment, and significantly increasing prices, inducing increasing risks and direct costs for many households. The crises put more attention on economic news which, together with the costs and risks, should induce households to update their information sets more often, all in accordance with the theory of rational inattention. The incentives to update their information should allow them to improve their expectations of inflation and make expectations more rational.

It is possible, however, that the crises put households in a situation so extreme and unfamiliar that they made even greater mistakes than before in forming their expectations concerning inflation. Many households had not faced an economic crisis of the same magnitude before, which required them to have a rather advanced analytical capacity and deep understanding of the new economic situation. This is an economic situation that many economists had difficulties analysing, and that put into question traditional models and analytical frameworks (Blanchard et al. 2010).

The effect of extraordinary and transforming events on rationality

Along the same lines, the following two hypotheses test the implications of extraordinary events that also significantly change economic conditions:

H4: Households in member states that experience more severe crises form more rational expectations than households in member states that experience less severe crises.

H5: Households in member states that switch currency to the euro are more rational after the switch.

The global financial crisis that started in 2007 was not one crisis, but a combination of several different kinds of crises, often intertwined with one another (see, e.g., Claessens and Kose 2013; Reinhart and Rogoff 2015). Almost all countries faced volatile financial markets; others experienced a banking crisis, sovereign debt crisis, or a currency crisis — often in combination. For some countries, the crises were more severe than for others, to the point where the crises became systemic and threatened the functioning of the financial system at large. For a few countries, the economic crises became so severe that they experienced or were threatened by financing difficulties that required them to request assistance from other member states and the International Monetary Fund. The assistance offered was accompanied

by conditions for economic reforms, a so-called economic programme. Other member states introduced the euro, which changed the unit of account in the respective member states. Both events generated media coverage, new risks, and incentives for households to inform themselves and potentially form updated and more accurate expectations.

Nevertheless, the situation households faced in the hardest hit countries — mainly programme countries — were more severe than in other member states, and therefore more difficult to assess. To the extent that the financial and the economic crises made it more difficult for households to form expectations, this would be even more the case in the hardest hit programme countries. Furthermore, most member states with a programme are less advanced in terms of economic development, as evidenced by lower GDP per capita, but also are less advanced in terms of financial literacy (Standard & Poor's Ratings Service 2015). Thus, even though the incentives for households to update their information and expectations concerning inflation were present, their ability to do so might have been impeded relative to other member states less affected by the crises.

Concerning the hypothesis related to the cash changeover to the euro, the test may also be ambiguous. Although euro introduction is a significant event, with campaigns informing households about the change and incentives for households to at least temporarily inform themselves, there is significant evidence that the euro introduction put people off in terms of forecasting inflation (see, e.g., Ehrmann 2006; European Commission 2002; Traut-Mattausch et al. 2004).

The effect of the inflation environment on rationality

The last hypothesis concerns the level of inflation in the economy, which changes the cost related to inflation that households face:

H6: Households become less rational in periods of low inflation.

In a low-inflation environment, the cost of inflation and price volatility declines, making it less important for households to pay attention to price developments. To the extent households update their information set less, and pay less attention to price movements in general, their expectations on future inflation should be less in line with rational expectations. However, households may resort to low-cost strategies — a rule of thumb approach which, in effect, may lead households to produce better forecasts of inflation at times of low inflation, i.e. more in line with rational expectations, than at times of high inflation. For example, a household assigning a low constant as its expectation

of future inflation when inflation is low and a high constant when inflation is high, will on average produce better forecasts of inflation when inflation is low, as inflation volatility is lower at low inflation rates (Judson and Orphanides 1999).

All tests of the hypotheses concerning rational inattention rely on events that bring about significant change in the economic environment. While the hypothesis is that these events induce people to inform themselves, the complexity of the economic environment also increases. Muth (1960) pointed out that when there is a significant regime change recent past information is more important for households than being forward looking in forming their expectations, as they learn about the dynamics of the new regime. These two opposing forces makes the hypotheses open ended; the results can go in either direction. Ultimately, it is an empirical question as to what extent households behave rationally in accordance with the theories of rational expectations, rational inattention, or neither.

2.3 Model and tests

This section presents the model used for testing the different hypothesis versus the null hypothesis that households form expectations in a rational or rationally inattentive manner. The tests explore both the weak-form and strong-form of rational expectations, and how these change as a result of economic events. The various tests impose different assumptions on the households' information set and make use of specific events during the sample period that may induce households to update them, i.e. to form inattentive rational expectations.

Hypothesis 1 — Weak rationality

With weak-form rational expectations, Hypothesis 1, people make optimal use of all public information available to them that, in their view, matter for assessing the future development of a relevant economic variable. The weak form of rational expectations is closely related to that of unbiasedness, and the two concepts have been intermingled in previous research (see, e.g., Jonung and Laidler 1988). In the context of households' inflation expectations, rational households should form expectations about inflation that make optimal use of their information; there is no restriction placed on the information. Weak-form rational expectations imply that expected inflation should match the true inflation rate.

Hypothesis 1 is tested using the standard regression of the following form:

$$\pi_{t+12} = \alpha + \beta_{\pi^e}\pi^e_{i,t} + \varepsilon_{i,t} \quad (1)$$

Under the null hypothesis, α and β are equal to 0 and 1 at the same time (H_0: $\alpha = 0, \beta_{\pi^e} = 1$), where π_{t+12} is the officially measured HICP inflation rate of inflation 12 months ahead, $\pi^e_{i,t}$ is the expected inflation rate formed by individual i in month t, and $\varepsilon_{i,t}$ is the error term. Thus, for example, an expectation formed in January 2010 is compared with the 12-month rate of change in the HICP reported for January 2011.[4] This regression does not test whether all relevant information was used or whether households possess all relevant information. Therefore, the weak-form test is complemented by a strong-form test of rational expectations.

Hypothesis 2 — Strong rationality

With strong-form rational expectations, Hypothesis 2, people have access to all relevant information, including the structure of their environment, and make optimal use of this information to predict the future development of a relevant economic variable. In the context of households' inflation expectations, rational households should form expectations that are correct up to the point of unavoidable, or unsystematic, errors. Strong-form rational expectations imply that expected inflation forecasts should match that of the true inflation rate, and no other information should correlate with the expectation errors in a systematic way, which places a strong restriction on the information set.

Hypothesis 2 is tested by complementing regression (1) with a set of information variables that were known to households at the time when expectations were formed:

$$\pi_{t+12} = \alpha + \beta_{\pi^e}\pi^e_{i,t} + \boldsymbol{Z}_{i,t}\boldsymbol{\Gamma} + \varepsilon_{i,t} \quad (2)$$

In regression (2), $\boldsymbol{Z}_{i,t}$ is a set of five information variables that were known to households at the time when expectations were formed, and $\boldsymbol{\Gamma}$ is a vector of regression coefficients. For households to use their information efficiently, the information in $\boldsymbol{Z}$ should not correlate with expectation errors, i.e. the null

[4] The timing of the data collection of the survey data and the prices underlying the calculation of the HICP is not perfect. The data collection for the consumer surveys, in general, are conducted during the first two weeks of the month, and the price collection takes place across at least one working week period at, or near, the middle of the calendar month to which the index pertains. Therefore, there is some discrepancy between a household's forecast horizon and the date of the value used to compare it with.

hypothesis is that the coefficients in vector $\mathbf{\Gamma}$ are all zero at the same time as α and β are equal to 0 and 1 (H_0: $\alpha = 0, \beta_{\pi^e} = 1, \mathbf{\Gamma} = 0$).

Hypotheses 3, 4, 5 and 6 — Rational inattention

To test Hypotheses 3, 4, 5 and 6, regression (2) is further augmented with an additional set of dummy and interaction variables $\boldsymbol{D}_{i,t}$, testing for different aspects of rational inattention:

$$\pi_{t+12} = \alpha + \beta_{\pi^e}\pi^e_{i,t} + \boldsymbol{Z}_{i,t}\mathbf{\Gamma} + \boldsymbol{D}_{i,t}\mathbf{\Lambda} + \varepsilon_{i,t} \quad (3)$$

Matrix $\boldsymbol{D}_{i,t}$ contains three dummy variables identifying if households are located in countries that have experienced two, three, or four types of crises (H3 and H4), a dummy variable identifying households in countries that changed their currency to the euro (H5), and a dummy variable identifying low inflation periods (H6). In addition to these five dummy variables, there is a set of six interaction variables for each dummy variable. These are formed by multiplying each dummy variable with expected inflation ($\pi^e_{i,t}$) and the five information variables ($\boldsymbol{Z}_{i,t}$). For both weak- and strong-form rational expectations to hold, all λ-coefficients should jointly be zero (H_0: $\mathbf{\Lambda} = 0$). However, if the two null hypotheses H1 and H2 are rejected, households may update their expectations at certain times, and then the λ-coefficients may be significant, shifting expectations further away or closer towards a more rational representation of regression (3).

Full regression specification

To complete the specification, the regression is augmented with a set of 54 additional country-specific terms (27 constants and 27 slope coefficients) and a common time pattern (or time effects) represented by a sequence of time dummies, one for each month in the sample. The country dummies control for the large heterogeneity in replies among national surveys, both in terms of the level of the bias (the constant) and the slope coefficient of expected inflation. They also allow for illustrating country-specific results of the tests. The time dummies control for the relatively large swings in inflation that took place during the crisis in Europe.

The full specification of the estimated regression is:

$$\pi_{n,t+12} = \sum_{n\in N}\alpha_n + \sum_{n\in N}\beta_{\pi^e,n}\pi^e_{i,n,t} + \gamma_O Z^O_{i,t} + \gamma_R Z^R_{i,t} + \gamma_U Z^U_{i,t} + \\ + \gamma_{Q1} Z^{Q1}_{i,t} + \gamma_{Q2} Z^{Q2}_{i,t} + \sum_{c\in C}\left(\lambda^\alpha_c D^c_{i,t} + \lambda^\pi_c \pi^e_{i,t} D^c_{i,t} + \lambda^O_c Z^O_{i,t} D^c_{i,t} + \right.$$

$$+\lambda_c^R Z_{i,t}^R D_{i,t}^c + \lambda_c^U Z_{i,t}^U D_{i,t}^c + \lambda_c^{Q1} Z_{i,t}^{Q1} D_{i,t}^c + \lambda_c^{Q2} Z_{i,t}^{Q2} D_{i,t}^c) + \\ + \sum_{m \in M} \mathrm{T}_m + \varepsilon_{i,t} \,, \quad (4)$$

where $N = \{All\ EU\ member\ states\ except\ HU\}$, $C = \{F2, F3, F4, E, I\}$ and $M = \{All\ months\ January\ 2004\ to\ May\ 2014\}$.

In total, regression (4) contains 218 terms. The first 54 are the country-specific constants and the households' expected inflation rates over the coming 12 months. The following five terms — the information matrix $\boldsymbol{Z}_{i,t}$ — represents the households' national price of motor fuels (O), the three-month interest rate (R), the unemployment rate (U), the households' individual view of the change in their respective financial situation over the last 12 months (Q1), and their view of how their financial position will change over the next 12 months (Q2). The fuel prices, the interest rates, and the private information on the household's financial situation are contemporaneous information, while the unemployment rate is lagging households' expectations by two months, in accordance with the release schedule of Eurostat.

Next are five sets of seven variables — the dummy matrix $\boldsymbol{D}_{i,t}$ — representing different economic conditions and events: the financial crisis depending if countries experienced two, three or four types of crises (F1, F2 and F3), the period after a country changed their national currency to the euro and joined the euro area (E), and low-inflation periods (I). All this information should in principle already be reflected in households' expectations and have no additional explanatory power. The regression is estimated with least squares, and clustered errors by month are used for the significance tests.

One potential issue regarding testing the hypotheses on rational inattention in this setting relates to the uncertainty involving the dating of events and by when new information reaches households, which may lower the estimated coefficients and bring them closer to zero, and bias the results towards insignificance. The dates for euro introduction in some EU member states are clearly known, planed and announced well in advance, and should not suffer from this problem. The crisis dates and the periods of low inflation are determined after they occurred, based on historical events and data, and can be affected by subjective methodological and judgemental choices. However, the crisis dates are determined and published by the System of European Central Banks and the European Systemic Risk Board, using state of the art methodological tools and expert judgement. The low-inflation periods are defined below, specifically for this chapter, and it is unclear how quickly new information on inflation can be absorbed by households, which therefore merit a minimum of sensitivity tests of the results.

2.4 Data

The reference data used as the dependent variable for testing consumers' rationality when forming their inflation expectations is the household's respective national year-on-year rate of change in the harmonised index of consumer prices (HICP), as published by the European Central Bank (ECB).[5]

The main independent variable is consumers' inflation expectations, and the data used come from the Harmonised Consumer Survey for the European Union (European Commission 1997, 2006, 2016). National institutes in each of the 28 participating countries conduct the surveys. The harmonised questionnaire contains questions on the economic situation of the household and the country where the respondent resides. It also contains information on the socioeconomic characteristics of the household. Parallel with two qualitative questions on price developments, two additional price questions were introduced in 2003 on an experimental basis. These two questions ask respondents to quantify past and future inflation and give their responses in percentages. The survey questions on future inflation — questions 6 and 61 in the standardised questionnaire — are the following:

Q6 By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will: (1) increase more rapidly; (2) increase at the same rate; (3) increase at a slower rate; (4) stay about the same; (5) fall; (N) don't know.

Q61 If question 6 was answered by 1, 2, 3, or 5: by how many percent do you expect consumer prices to go up/down in the next 12 months? (Please give a single figure estimate): Consumer prices will increase by……,…% / decrease by……,…%.

It is the quantitative measure of inflation expectations that is particularly useful for testing how rational households are when forming expectations. Without this measure, researchers must resort to different quantification methods to transform qualitative data into quantitative content, giving rise to less reliable data. Also, the qualitative question is more complex, as it requires respondents to be able to differentiate between different concepts of price developments:

[5] It is standard practice in this type of research to use the officially measured inflation rate as the benchmark for comparing households' inflation expectations, as there is no better alternative available. However, to what extent it corresponds to what households perceive as inflation is an open question. There is also an ongoing academic discussion on what to include in the indexes of inflation (see Goodhart 2001; Bryan et al. 2002). Both issues may have bearing on the results of this chapter.

the price level, the rate of change in the price, and the change in the rate of change in the price. The quantitative question, on the other hand, is more straight forward, as it pertains to price increases in general. However, the question does not refer to the HICP rate of inflation explicitly. Nevertheless, with representative surveys, there should be strong correspondence between the two. For a more comprehensive description of the harmonised-EU-survey programme, see European Commission (1997, 2006, 2016).

Table 1: Descriptive statistics of households' inflation expectations, January 2004 to May 2014
Distribution of households' quantitative estimates of expected inflation, Jan 2004 to May 2014. In all calculations, an equal weight is applied to all responses.

	DESCRIPTIVE STATISTICS	
STATISTICS	FULL SAMPLE	TRIMMED SAMPLE
Min (%)	-500.0	-33.0
25th percentile (%)	0.0	0.0
Mean (%)	8.5	6.6
Median (%)	5.0	4.0
75th percentile (%)	10.0	10.0
Max (%)	900.0	100.0
Mode (%)	0.0	0.0
Relative frequency of mode (%)	27.2	29.3
Total number of respondents	3 183 807	2 953 512

The dataset is comprehensive and contains more than 3 000 000 observations on households' inflation expectations. It comprises more than 10 years of monthly data, from January 2004 to May 2014, and includes individual observations from 28 member states of the EU at the time. However, Hungary is excluded from the analysis, because there is only one month of data available. Hence, the analysis covers 27 member states. There are also other issues with the dataset. First, as shown in Table 1, there are several outliers. Second, expectations differ significantly across countries. Third, for some member states data are missing in some periods, either due to experiments in the early days of the dataset, or because the quantitative questions were not asked. For these reasons, data are not available for Croatia between January 2004 and December 2005, for Germany between August and October 2007, for France every August until 2007, for the Netherlands between May 2005 and May 2011, and for Spain September 2005. For other issues with the data, see European Commission (2006) and Arioli et al. (2016).

As the data contain numerous extreme values, they are trimmed. The amount and magnitude of the outliers differ across countries, which warrants using an approach that takes the distribution of replies into account. The method applied

selects all responses that fall within the range of the 2nd to 3rd quartile, plus or minus 1.5 times the interquartile range of the 2nd to 3rd quartile. Thus, observations are considered outliers if they are larger than q3 + 1.5(q3 – q2) or smaller than q2 – 1.5(q3 – q2), where q1 and q3 are the 25th and 75th percentiles, respectively. The value of 1.5 corresponds to approximately +/– 2.7 standard deviations and a 99.3% coverage if the data are normally distributed. This truncation affects about 10% of all expected inflation rates. Several other trimming methods have also been applied. They do not influence the results in any material way, except the level of the average expected inflation rates.[6]

Note, although there are around 3 million observations on inflation expectations, the dependent variable in the estimated regression is the national HICP rate of inflation, which is the same for all households in any specific country and month. This significantly reduces the effective number of observations to the number of countries times the number of months that the dataset spans. In total there are 3 270 individual pairs of country and monthly observations. However, all expectation observations are used in estimating regression 4, which may lead to the inference suffering from what is called the p-value problem (see Lin et al. 2013). With very large samples, as in this case, p-values quickly go towards zero, which can lead to conclusions that are of no practical relevance, and increase the likelihood of false positives. To deal with this issue, the results are discussed not only in terms of statistical significance, but also in terms of 'economic significance'.

Hypothesis 1 and 2 — Weak and strong rationality

Testing the different forms of rational expectations also involves identifying a set of information variables that were known to households at the time when expectations were formed. There are five information variables, which can be classified into two groups. The first group contains three publicly available market and macroeconomic data series: (i) the households' national price of motor fuels; (ii) the three-month interest rate; and (iii) the unemployment rate. The second group contains information which is private to the household; this is more micro-oriented data: (iv) the households' individual view of the change in their respective financial situations over the last 12 months; and (v) their view of how their financial position will change over the next 12 months. The first set of information requires some degree of gathering by the household,

[6] See Lindén (2010) and European Commission (2006) for a brief description of some of the methods applied.

and it is publicly available to all households. The second set, the household's economic situation, is directly available and is private to each individual household. Both sets of data, however, may require costly processing to constitute valuable information for forming expectations about inflation.

Specifically, the data used and the sources are the following: Fuel prices are the weighted average consumer price of petrol and diesel collected from the weekly oil bulletin of the European Commission, which reflects price and tax differences across member states. The interest rates are the three-month interbank rate for each country or currency area, collected from Datastream, and the unemployment rate is the harmonised version published by Eurostat, the statistical office of the European Union. The two variables on a household's financial position are the household's respective answer to questions one and two in the harmonised questionnaire of the EU Harmonised Consumer Survey (see European Commission 2016).

In addition, the analysis requires the identification of a set of dates and time periods to be used for generating dummy variables applied in the regression analysis. These dates concern the onset and end of any systemic financial and economic crisis that a county faced during the sample period, the date for a euro-cash changeover, and months of low inflation.

Hypothesis 3 — The effect of economic crises on rationality

The ECB and the European Systemic Risk Board (ESRB) have developed a new database for financial crises in European countries, which is applied to generate a set of dummy variables used in the rationality tests. The database contains a chronology of crisis periods from 1970, designed to support the calibration of models in macro-prudential analysis. However, the design is suitable for other applications as well that require a proper dating and identification of crises. To identify crisis periods, the ECB and the ESRB have combined a quantitative approach based on a financial stress index with expert judgement from national and European authorities. For details about the construction of the database, see Lo Duca et al. (2017).

For the purpose of this chapter, the database contains information on the starting date of a crisis period and the end of crisis management date, which can be seen as the acute phase of the crisis. Besides the two dates used to define the beginning and the end of a crisis period, the database contains a system 'back to normal' date, which is not used. The main reason is that the definition of a system being back to normal requires monetary policy to have been normalised. There is a problem with applying those dates in the tests for both

euro area and non-euro area countries. For the countries in the euro area this is a problem, as there are several countries that are clearly no longer in a crisis (e.g. Germany), while others clearly are (e.g. Greece), and monetary policy is set for the euro area as a whole, with ongoing quantitative easing and very low policy interest rates. As a result, no euro-area member state has a system that can be classified as back to normal. The same is true for Denmark and Sweden, where national authorities seem to have judged their respective monetary policy stance differently, i.e. Denmark's system is back to normal as of December 2013, while in Sweden the crisis is still ongoing. Neither country has any significant sign of an ongoing financial crisis.

The database also classifies each crisis in one or more non-mutually exclusive categories: (i) currency/balance of payment (BoP)/capital flow crisis, (ii) sovereign crisis, (iii) banking crisis, and (iv) crisis with significant price correction. The categories are simplifications, but provide an indication of the type of risks that materialised. They also give an indication of how complex or

Table 2: Overview of the applied systemic crises in the database

			TYPE OF CRISIS				
Country	Start date	End of crisis management	Currency / BoP / Capital flow	Sovereign	Bank	Significant asset price correction	№ of crises
AT	2007-12	2016-04	0	0	1	1	2
BE	2007-11	2012-12	0	0	1	1	2
DE	2007-08	2013-06	0	0	1	1	2
DK	2008-01	2013-12	0	0	1	1	2
FR	2008-04	2009-11	0	0	1	1	2
LT	2008-12	2009-11	0	0	1	1	2
LU	2008-01	2010-10	0	0	1	1	2
NL	2008-01	2013-02	0	0	1	1	2
RO	2007-11	2010-08	1	0	0	1	2
SE	2008-09	2010-10	0	0	1	1	2
UK	2007-08	2010-01	0	0	1	1	2
LV	2008-11	2010-08	1	0	1	1	3
SI	2009-12	2014-12	0	1	1	1	3
CY	2011-06	2016-03	1	1	1	1	4
ES	2009-03	2013-12	1	1	1	1	4
GR	2010-05	Ongoing	1	1	1	1	4
HR	2007-09	2012-06	1	1	1	1	4
IE	2008-09	2013-12	1	1	1	1	4
IT	2011-08	2013-12	1	1	1	1	4
PT	2008-10	2015-12	1	1	1	1	4

Source: European Central Bank and European Systemic Risk Board, 2017

Note: Balance of payment (BoP); Start and end of crisis dates are denoted by year and month (YYYY-MM). For country names and abbreviations see Table A1.

severe a crisis period was. All crisis episodes entail the materialisation of at least two different risks. Table 2 presents the dates of the crisis events and the different types of crises that occurred during that period.

Hypotheses 4 and 5 — The effect of extraordinary and transforming events on rationality

Essential for the analysis is also defining the two extraordinary events: differentiating member states on the severity of crisis experienced and whether a member state introduced the euro or not.

The number of interacting crises indicate the complexity, but also the severity, of a crisis event that any individual country has experienced. Based on the number of types of crises in Table 2, a set of three dummy variables are constructed, where each household is represented with a 1 if they lived in a country that experienced respectively two, three, or four different types of crises at the time of the survey, and 0 otherwise. One indication that these dummy variables distinguish countries in terms of severity of crisis is that countries that experienced two types of crises performed relatively better in terms of growth in gross domestic product than those that experienced four types of crises. Furthermore, among those countries that experienced four types of crises, five — Cyprus, Greece, Ireland, Portugal and Spain — were not able to finance themselves on the bond market and became subject to IMF-EU rescue programmes.

Between 2004 and 2014, six countries introduced the euro: Slovenia (January 2007), Cyprus (January 2008), Malta (January 2008), Slovakia (January 2009), Estonia (January 2011), and Latvia (January 2014). Based on these dates, a euro-cash changeover dummy is constructed, where each household residing in one of the six member states after the introduction date of the euro is represented with a 1, and 0 otherwise.

Hypothesis 6 — The effect of low or high inflation periods on rationality

The low inflation periods are defined as the months below the 25th percentile of the distribution of the year-on-year rate of change in the harmonised index of consumer prices. The low inflation dummy is constructed by assigning a 1 to all households responding to the survey in a month defined as a low inflation month, and 0 otherwise.

2.5 Results

This section presents the results of the different tests of expectation properties under the null hypothesis that households form expectations in a rational or rationally inattentive manner. The results are presented for three samples of the data: the full sample and two subsamples. The full sample is split into two subsamples, which distinguish households based on their level of education: one for households with basic education and the other for households with a higher level of education. The subsamples serve three purposes. First, they allow for checking the stability of the results. Second, they allow for testing whether there is a difference in rationality between those with basic and higher education. Third, they allow for comparing some of the results with other studies using education as an identifying variable. This seventh hypothesis is nothing that comes out of the theories of rational expectations or rational inattention. However, with education could come more knowledge and better capacity to process data, which could give rise to differences in the tests of rationality. As such, the question concerning education is equally relevant under each of the six hypotheses, and the results of any differences between the subsamples are presented under each separate heading of tested hypothesis.

2.5.1 Results of testing Hypotheses 1 and 2 — weak and strong rationality

Table 3a presents the first part of the results from estimating regression (4), testing hypotheses H1 and H2. The first column shows the results for the full sample. The following two columns show the results for two sub-samples, distinguishing households based on their level of education, i.e. basic education (primary and secondary schooling) and further education. The first row shows the values for the average of the 27 national constants (α_n), the national expectation biases, which for the full sample is 4.2 percentage points above the officially measured inflation rate. The second row shows the average of the 27 slope coefficients ($\beta_{\pi^e,n}$), which is 0.02. In this setting, there is no material economic difference in the bias between households with basic education and households with higher education. This finding is at odds with other findings using this type of survey data (see, e.g., Bryan and Venkatu 2001), where households with higher education usually produce expectations with lower biases. These coefficients, together with the coefficients in the following five rows, provide the information for testing the hypotheses of

Table 3a: Estimated coefficients of regression 4, testing the hypothesis of households forming weak and strong rational expectations of inflation one year ahead — Hypotheses 1 and 2

		SAMPLE		
ROW	COEFFICIENT	TOTAL	BASIC EDUCATION	FURTHER EDUCATION
(1)	Average constant (α_n)	4.22***	4.28***	4.38***
(2)	Average exp. inflation (β_{π^e})	0.02	0.02	0.02
	Information variables			
(3)	Fuel price (γ_O)	0.00	0.00	0.00
(4)	Interest rate (γ_R)	0.12***	0.16***	-0.02
(5)	Unemployment (γ_U)	-0.19***	-0.19***	-0.22***
(6)	Q1 (γ_{Q1})	-0.06***	-0.07***	-0.04***
(7)	Q2 (γ_{Q2})	-0.04***	-0.04***	-0.02***
	Tests			
(8)	H1: Wald stat. weak RE	>10 000***	>10 000***	>10 000***
(9)	H2: Wald stat. strong RE	>10 000***	>10 000***	>10 000***
(10)	R^2	0.683	0.691	0.678
(11)	№ of observations	3 270	3 270	3 270
(12)	№ of households	2 855 265	2 014 850	834 593

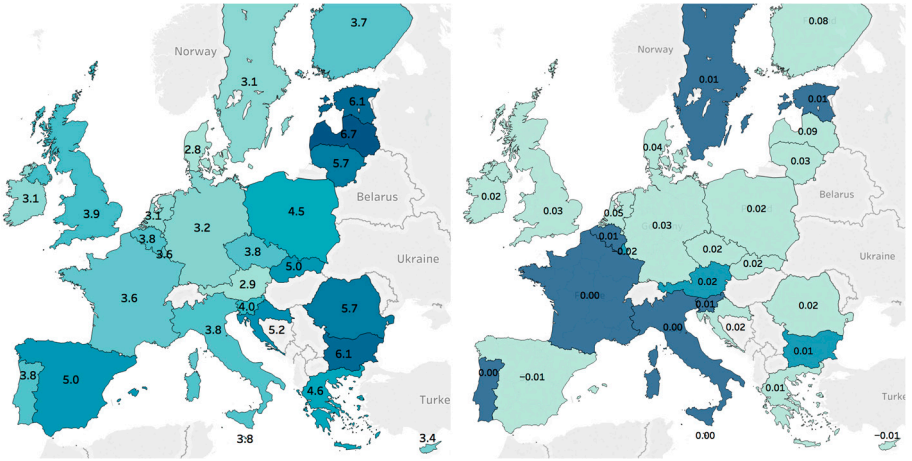
Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.

strong and weak rational expectations, with test statistics from the Wald tests in rows 8 and 9.

All three tests of Hypothesis 1 reject the null hypothesis of households forming weakly rational expectations of inflation (row 8), where the joint test — $\forall\, n\colon \alpha_n, \beta_{\pi^e,n} = (0,1)$ — is performed with a Wald test and clustered standard errors. Figure 1 presents all the national constants and slope coefficients for expected inflation. The constants α_n lie between 2.8 and 6.7 percentage points and are all significant at the 1% level (left map, the colour shading represents the strength of the bias), while the slope coefficients $\beta_{\pi^e,n}$ are all very close to zero (right map, the colour shading represents p-values below 2.5%, 5%, 7.5% and 10% and above). Still, the slope coefficients in 14 cases are significantly positive at the 5% level, and two are negative. There is no significant difference between the two education samples.

The Wald test of Hypothesis 2 on row 9 rejects the null hypothesis that households use information efficiently when forming inflation expectations, i.e. satisfying the conditions for strong-form rational expectations — $\forall\, n\colon \alpha_n = 0, \beta_{\pi^e,n} = 1, \mathbf{\Gamma} = 0$. For the full sample, the officially measured

Figure 1: Country-specific constants (left map) and slope coefficients (right map)
The values are the total expectation errors (the constants α_n) in percent (colour shading represents the strength of the bias) and the slope coefficients β_n from regression 4 (the coulour shading represents p-vlues below 2.5%, 5%, 7.5% and 10%, from ligther to darker coulour).



inflation rate correlates significantly with the short-term interest rates (0.12), the unemployment rate (-0.19), and how households perceive their past (-0.06) and future (-0.04) financial situation. Interestingly, however, the results indicate that households do make efficient use of the price of petrol and diesel, as the coefficient is not significantly different from zero. Besides fuel prices, the private information, households' views about their own economic situation generates the smallest expectation errors of the significant information variables. Note, however, that the coefficients are close to zero and imply that any change in the independent information variables would only have a marginal effect for improving expectations.

The results imply that households do not adjust their expectations in accordance with interest rates and unemployment and underestimate any changes present in these two variables, where increasing interest rates indicate rising inflation and higher unemployment indicates lower inflation. However, as expected, the impact is relatively weak, as the short-term interest rates and unemployment rates are slow-moving variables. Nevertheless, over time they may have a significant impact, which households seem to neglect when forming their inflation expectations, i.e. expectations are rather constant over time and do not vary with changing external economic conditions.

With one exception, the results are essentially the same for the two education sub-samples, for which both weak- and strong-form rational expectations are rejected. The official inflation rate correlates with the unemployment rate

(-0.19 and -0.22) and how households perceive their own past (0.07 and 0.04) and future (0.04 and -0.02) financial situation. Households with higher education take their financial situation slightly more into account than those with lower education when forming their expectations concerning inflation. The results, however, show that households with higher education take the short-term interest rate into account when forming their expectations, as the coefficient (-0.02) is not statistically different from zero.

Overall, the results show that households are not rational in the sense of Muth (1961). The strong and persistent expectation biases in conjunction with the very low, and economically irrelevant, slope coefficients indicate that households do not update their expectations often and are rather insensitive in taking available information into account. These results are consistent with households that put a constant amount of resources and effort into forming expectations. Possibly, it also indicates that households do not fully understand the concept of inflation and other macroeconomic variables.

2.5.2 Results of testing Hypotheses 3, 4, 5 and 6 — rational inattention

Given the results in Section 2.5.1, where the hypotheses that households form rational expectations are rejected, the tests of whether households are inattentively rational in times of crisis, or when exceptional events take place, shift from testing $H_0: \Lambda = 0$ to whether the coefficients move in a direction that would improve households' rationality. For example, if the bias declines and the slope coefficient for expected inflation increases, this would constitute a move by households towards more rationally-formed expectations. Such a move would be in line with the hypothesis that households behave in a rational inattentive manner.

Hypothesis 3 — The effect of economic crises on rationality

Almost all tests of Hypothesis 3 reject the null hypothesis of households becoming more rational in the weak sense during the financial crises, where the tests are $\lambda^{\alpha}_{F2}, \lambda^{\alpha}_{F3}, \lambda^{\alpha}_{F4} < 0$ and $\lambda^{\pi}_{F2}, \lambda^{\pi}_{F3}, \lambda^{\pi}_{F4} > 0$. Table 3b presents the results on the first two rows of each panel, i.e. member states that experienced two, three, or four types of crisis. With the financial crisis, households become less rational, as the estimated coefficients change in a direction that is not consistent with improved rationality. The bias in households' inflation expectations — λ^{α}_{F2}, λ^{α}_{F3} and λ^{α}_{F4} — increase by 1.75, 0.74, and 0.77 of a

Table 3b: Estimated coefficients of regression 4 continued, testing the hypothesis that economic crises affect households' rationality and that households form more rational expectations in a more severe crisis — Hypotheses 3 and 4

ROW	COEFFICIENT	SAMPLE TOTAL	BASIC EDUCATION	FURTHER EDUCATION
	Financial crisis (2)			
(1)	Constant (λ^{α}_{F2})	1.75***	1.81***	1.76***
(2)	Expectation (λ^{π}_{F2})	-0.02**	-0.02	-0.04***
(3)	Fuel price (λ^{O}_{F2})	-0.01***	0.00	-0.02***
(4)	Interest rate (λ^{R}_{F2})	0.02	0.00	0.06*
(5)	Unemployment (λ^{U}_{F2})	-0.20***	-0.20***	-0.19***
(6)	Q1 (λ^{Q1}_{F2})	0.06***	0.07***	0.04***
(7)	Q2 (λ^{Q2}_{F2})	-0.01	0.00	-0.02**
	Financial crisis (3)			
(8)	Constant (λ^{α}_{F3})	0.74	0.82	0.35
(9)	Expectation (λ^{π}_{F3})	-0.03**	-0.03**	-0.03**
(10)	Fuel price (λ^{O}_{F3})	0.11***	0.11***	0.10***
(11)	Interest rate (λ^{R}_{F3})	-1.52***	-1.58***	-1.29***
(12)	Unemployment (λ^{U}_{F3})	-0.03	-0.04	0.02
(13)	Q1 (λ^{Q1}_{F3})	-0.04**	-0.04*	-0.06**
(14)	Q2 (λ^{Q2}_{F3})	-0.02	-0.01	-0.07**
	Financial crisis (4)			
(15)	Constant (λ^{α}_{F4})	0.77***	0.91***	0.15
(16)	Expectation (λ^{π}_{F4})	0.00	-0.01	0.00
(17)	Fuel price (λ^{O}_{F4})	0.01***	0.01***	0.01*
(18)	Interest rate (λ^{R}_{F4})	-0.13***	-0.16***	-0.02
(19)	Unemployment (λ^{U}_{F4})	0.07***	0.08***	0.09***
(20)	Q1 (λ^{Q1}_{F4})	-0.12***	-0.11***	-0.13***
(21)	Q2 (λ^{Q2}_{F4})	-0.14***	-0.14***	-0.13***
	Coefficient tests			
(22)	H0: $\lambda^{\alpha}_{F2} - \lambda^{\alpha}_{F4} = 0$	0.98***	0.90***	1.60***
(23)	H0: $\lambda^{\pi}_{F2} - \lambda^{\pi}_{F4} = 0$	-0.02*	-0.01	-0.05***

Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.

percentage point during the crisis, although the increasing bias in countries with three types of crises is not significantly different from zero. At the same time, their inflation expectations — λ^{π}_{F2}, λ^{π}_{F3} and λ^{π}_{F4} — are less relevant for explaining HICP inflation, i.e. the coefficients are significantly negative, or insignificantly different from zero. The increase in the bias is economically relevant, while the change in the slope coefficients are not, as the coefficients are close to zero. The increasing biases and households' expectations explaining less of what is happening in the HICP rate of inflation, imply that they are not adjusting their expectations sufficiently to take the new situation

into account. These two results add to the previous ones, showing households becoming even less rational in the weak sense, i.e. the constant and the slope coefficient are creeping further away from zero and one, respectively.

In general, households made less efficient use of the tested information variables during the episode of the financial crisis. For the total sample, the interaction variables change significantly in a direction consistent with increased rationality in 4 out of 15 cases, i.e. for households' past financial situation in countries with two types of crises (λ_{F2}^{Q1}, row 6 in Table 3b), the short-term interest rate in countries with three or four types of crises (λ_{F3}^{R} and λ_{F4}^{R}, rows 11 and 18), and the unemployment rate in countries with four types of crises (λ_{F4}^{U}, row 19). In seven cases the households made a significantly less efficient use of the information tested.

There is also no material difference between the two subsamples in the sense that most coefficients move in the same direction for the two subsamples, although with some difference in significance. The biggest difference concerns the bias in inflation expectations for households with further education in countries with four types of crises, which is not significantly different from zero.

Overall, there is only little or no evidence that households behave in an inattentively rational manner because of the financial crisis. Rather, the results are consistent with households that behave in a general inattentive manner, as they don't change their expectations with regard for the new economic situation. Instead the expectation errors increase and changes in readily available information continue to not be taken into account.

Hypotheses 4 and 5 — The effect of extraordinary and transforming events on rationality

Tests of Hypothesis 4 partially accept the hypothesis that households in member states that experienced a more severe crisis form more rational expectations than households in countries that experienced a less severe crisis. Table 3b presents the results from testing whether the bias in countries with two types of crises is equal to the bias in countries with four types of crises $\lambda_{F2}^{\alpha} - \lambda_{F4}^{\alpha} = 0$, row 22). For all samples, households in countries with four types of crises make significantly smaller mistakes in forming their expectations, which may be taken as a signal that a severe crisis induces some households to partially update their information set. This difference is also of a magnitude that is economically relevant, in the order of a percentage point or more. This notion is reinforced by households with further education showing

no additional bias in countries with four types of crises (λ_{F4}^{α}, row 15). Furthermore, households in countries with four types of crises do not make any additional mistakes regarding the slope coefficients (λ_{F4}^{π}, row 16). However, relative to households experiencing two types of crises, the differences are not significant, except for households with further education.

Households experiencing a more or a less severe financial crisis also make different use of information, where households in countries that experienced four types of crises make better use of information on interest rates and unemployment (λ_{F4}^{R} and λ_{F4}^{U}, rows 17 and 18). Interest rates are even used efficiently in times of crisis, while the use of unemployment is improved significantly. However, the private information on the household's past and future economic situation is used less efficiently (λ_{F4}^{Q1} and λ_{F4}^{Q2}, rows 20 and 21), as the coefficients add to the bias significantly. Households experiencing two types of crises, on the other hand, improve their use of their private information on the household's past economic situation to the point that it is used efficiently during a crisis (λ_{F2}^{U}, row 6). Furthermore, those households with further education also make efficient use of the information on interest rates.

Although Hypothesis 4 is partially accepted in the sense that in general the biases are smaller when the crisis is more severe, and parts of the information set are used more efficiently, the results are not consistent with the theory of rational inattention. The biases remain large and other parts of the information set are used less efficiently and are of little economic importance. Furthermore, some of the differences between the coefficients in the two panels of severity of crisis are not significant. The results are rather consistent with households that form expectations based on a rule of thumb, but that in an extreme event have made a one-off partial adjustment of their inflation expectations.

Note that, in testing Hypothesis 4, countries with three types of crises are disregarded — for two reasons. First, there are only two countries with relatively few observations. Second, by focusing on the difference between countries with two and four types of crises, the difference in severity of crises becomes more distinct.

Table 3c: Estimated coefficients of regression 4 continued, testing the hypothesis of households in member states that switched their national currencies to the euro became more rational after the switch — Hypothesis 5

ROW	COEFFICIENT	SAMPLE TOTAL	BASIC EDUCATION	FURTHER EDUCATION
	Euro introduction			
(1)	Constant (λ_E^{α})	-0.97***	-0.82***	-1.62***
(2)	Expectation (λ_E^{π})	0.01*	0.01	0.01**
(3)	Fuel price (λ_E^{O})	0.01***	0.02***	0.00
(4)	Interest rate (λ_E^{R})	0.14**	0.12**	0.20***
(5)	Unemployment (λ_E^{U})	0.02	0.02	0.06***
(6)	Q1 (λ_E^{Q1})	0.08***	0.09***	0.09***
(7)	Q2 (λ_E^{Q2})	0.06***	0.06***	0.09***

Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.

Tests of Hypothesis 5 partially accept the hypothesis that households in member states that switched their national currencies to the euro became more rational after the switch. The results in Table 3c show that in general households in countries that introduced the euro form less biased inflation expectations, and partially make better use of the tested information. After the euro-cash changeover, the expectation bias (λ_E^{α}, row 1) declines significantly by almost one percentage point in the total sample, and by 1.6 percentage points in the sample of households with further education. The average bias before the euro introduction is 4.8 percentage points above the officially measured inflation rate. The slope coefficients, however, do not increase in any material way, i.e. inflation expectations (λ_E^{π}, row 2) did not become more relevant for explaining inflation.

Households in member states that introduced the euro made more efficient use of private information on the economic situation of the household, but less efficient use of the short-term interest rates. The coefficients for both the past and the future economic situation of the household increased significantly (λ_E^{Q1} and λ_E^{Q2}, rows 6 and 7), to the extent that the information is used in line with the strong-form of rationality. However, the interest rates, which should have been an important variable in the run-up to the euro-cash changeover, are used less efficiently, as the coefficients (λ_E^{R}, row 4) are significantly positive and add to the bias. The coefficients for fuel prices and unemployment are mainly insignificant, although it is worth noting the households with further education make more efficient use of the unemployment rate after euro introduction. These coefficients are yet again close to zero and of little economic importance.

These results are consistent with those of Hypothesis 4, in the sense that Hypothesis 5 is partially accepted, as the biases are smaller and parts of the information set are used more efficiently. However, the results are yet again not consistent with the theory of rational inattention, as the biases remain large and other parts of the information set are used less efficiently. The results are yet again rather consistent with households that form expectations based on a rule of thumb and, in an extreme event, have made a one-off partial adjustment of their inflation expectations.

The results from testing Hypothesis 5 also show interesting differences from those of other studies that show that the euro introduction made it more difficult for households to form expectations regarding inflation. In the first round of euro-cash changeovers in 2002, households in many member states felt they experienced a significant increase in inflation, even though the official rate only changed marginally (see, e.g., Ehrmann 2006). This difficulty should have induced households to update their information sets, yet the results show they did not. However, the results in Table 3c show that, in member states taking part in later rounds of euro introduction, the biases in households' inflation expectations decline.

Hypothesis 6 — The effect of low or high inflation periods on rationality

Tests of Hypothesis 6 reject the hypothesis that households become less rational in periods of low inflation.[7] Table 3d shows that periods of lower inflation induce households to shift their inflation expectations down, while the expectations lose some of their explanatory power. The expectation bias (λ_I^{α}, row 1) declines significantly by 0.8 of a percentage point, which is not consistent with the theory of rational inattention. However, households' inflation expectations become less relevant for explaining inflation (λ_I^{π} declines, row 2), which is in accordance with the theory of rational inattention.

[7] As there is some uncertainty to when households are able to absorb and process new information on inflation developments, regression 4 has also been estimated using lagged dates for low-inflation periods, to check the sensitivity of the results. Assuming that it takes more time for lower inflation to enter into households' expectations about inflation, later inflation expectations may perform better. Regression 4 is therefore estimated using a 3, 6 and 12 month lag to the low-inflation periods. There are no material differences to the estimated parameters. Hypothesis 6 is rejected in the same way as in the original specification of regression 4, and the value of the coefficients are similar, with few differences in significance. The main difference is that the expectation bias (λ_I^{α}) declines slightly less, the larger the lag.

Table 3d: Estimated coefficients of regression 5, testing the hypothesis of households becoming less rational in periods of low inflation — Hypothesis 6

ROW	COEFFICIENT	SAMPLE TOTAL	BASIC EDUCATION	FURTHER EDUCATION
	Low inflation			
(1)	Constant (λ_I^a)	-0.80***	-0.89***	-0.62***
(2)	Expectation (λ_I^π)	-0.03***	-0.03***	-0.03***
(3)	Fuel price (λ_I^Q)	-0.01**	-0.01*	-0.01**
(4)	Interest rate (λ_I^R)	-0.03	0.00	-0.08
(5)	Unemployment (λ_I^U)	0.01	0.01	0.01
(6)	Q1 (λ_I^{Q1})	0.10***	0.11***	0.07***
(7)	Q2 (λ_I^{Q2})	0.07***	0.07***	0.06***

Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.

The empirical results also show that, during periods of low inflation, households make more efficient use of the tested information, but this may simply be because such information is less important when inflation is low. The coefficients for the interaction variables for households' views of their own past (λ_I^{Q1}, row 6) and future (λ_I^{Q2}, row 7) financial situation increase significantly during periods of low inflation and reduce the inefficient use of these information variables. The coefficient for short-term interest rates (λ_I^R, row 4) and unemployment (λ_I^U, row 5) are insignificantly different from zero, but have signs that are consistent with a more efficient use of these information variables. The results point to a more efficient, or at least not a worse, use of information during periods of low inflation. This is not consistent with the hypothesis that households become less rational in the strong sense during periods of low inflation. Moreover, the coefficients are close to zero.

The results show that households do not become less rational in periods of low inflation; the expectation bias declines and the tested information is used more efficiently. Households rather seem to resort to low-cost strategies, a rule of thumb approach, which in effect may lead them to produce better forecasts of inflation at times of low inflation, i.e. more in line with rational expectations. For example, a household assigning a low constant as its expectation of future inflation when inflation is low, and a high constant when inflation is high, will on average produce better forecasts of inflation when inflation is low, as inflation volatility is lower at low inflation rates (Judson and Orphanides 1999). The low slope coefficient and the fact that it does not change in any economically relevant way (β_{π^e} and λ_I^π are both close to zero) supports the notion that households resort to changing their expectations in occasional one-off steps.

2.6 Concluding remarks

To summarise, the purpose of this chapter is to explore to what extent households' inflation expectations are consistent with theories of rationality. Six hypotheses are tested by regressing households' inflation expectations, a set of information variables, and a set of dummy variables specifying events that may induce households to improve on their expectations on the official measure of inflation, the HICP rate of inflation. Table 4 summarise the results and shows that four hypotheses are rejected and two are partially accepted.

The results show that households do not form rational expectations in the sense of Muth (1961), and their rationality does not improve in times of crisis or at the time of a major economic event such as changing the domestic currency to the euro. The data suggest that households use a rather constant amount of resources and effort in forming expectations on inflation, except possibly in extreme situations when one-off changes to expectations are made. In times of economic crisis, the expectation bias increases; when inflation is low, the bias decreases. These results are rather consistent with households that use a rule of thumb approach in forming expectations, which implies that occasionally they perform better relative to the official inflation rate, and at other times worse.

Table 4: Results of testing the six hypotheses

HYPOTHESIS TESTED		RESULT
H1	Households form unbiased predictions of inflation 12 months ahead	Rejected
H2	Households' expectations are uncorrelated with any information available at the time the forecast is made	Rejected
H3	Households become more rational during a crisis period	Rejected
H4	Households in member states that experience more severe crises form more rational expectations than households in member states that experience less severe crises	Partially accepted
H5	Households in member states that switch currency to the euro are more rational after the switch	Partially accepted
H6	Households become less rational in periods of low inflation	Rejected

There is only weak empirical support in favour of the theory of rational inattention. When a crisis turns sufficiently extreme, as during the sovereign debt crisis in 2012, the cost of not updating ones' information set and thinking seems to become too costly. In this situation, households are induced to update and produce less biased expectations, relative to households experiencing less severe crises. Nevertheless, the biases increase regardless of the severity of crisis. Also, introducing the euro may be classified as an extreme event, but in this case the biases in inflation expectations decline. However, this decline is a one-off adjustment of the level of inflation expectations.

It should be noted: the sample used in this chapter contains three million observations on households' inflation expectations, and the question is how rational they actually are. Not very, it would seem. However, the answer may not be so simple: the results raise many questions. First, is the benchmark, the official inflation rate based on the Harmonised Index of Consumer Prices, measured correctly. Discussions exist on what should be included in the indexes of inflation, that is, should house and financial asset prices be included (see Goodhart 2001; Bryan et al. 2002)? Second, if it is measured correctly, does it correspond to what households perceive as inflation? For example, again, house- and stock market developments may influence households' views. Third, how well do people understand inflation and rates of change? Macroeconomic concepts are difficult to understand and are something that most people do not deal with on a regular basis in their daily lives. Fourth, do respondents to the surveys understand or interpret the questions correctly? The two qualitative price questions in the Harmonised Consumer Survey are complex and involve understanding and switching between three concepts of price developments: the price level, the rate of change (first derivative) in the price, and the change in the rate of change (second derivative) in the price. The quantitative questions are somewhat easier to understand, as they just ask about a number for the inflation rate. Nevertheless, this involves thinking in terms of percentages, which people have been found to struggle with, as shown by the survey questions used to calculate the Financial Literacy Index (Standard & Poor's 2015).

People may know more about their daily lives and their personal economy than about macroeconomic variables. The results in this chapter show that households make somewhat more rational use of their private information, i.e. the information on the household's past and future financial situation, especially the past information. The coefficients in general are lower than for the other information variables, and the efficient use of this information improves in certain cases. To add to this notion, Jonsson and Lindén (2009), in a paper trying to find the best survey indicator for consumption growth, show that questions related to personal economy perform better in tracking overall consumption than a combination of answers to questions that mainly relate to general economic developments. This suggests that digging deeper into the survey, looking at aspects of households that distinguish between those that are more and less informed could be relevant. This is particularly true if those aspects are directly relevant to the economic situation of the household and, at the same time, relate to inflation, or at least to the macroeconomy in general.

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2.8 Appendix

Table A1: Names and abbreviations of countries in the European Union

COUNTRY	ABBREVIATION	COUNTRY	ABBREVIATION	COUNTRY	ABBREVIATION
Austria	AT	Germany	DE	Poland	PL
Belgium	BE	Greece	GR	Portugal	PT
Bulgaria	BG	Hungary	HU	Romania	RO
Croatia	HR	Ireland	IE	Slovakia	SK
Cyprus	CY	Italy	IT	Slovenia	SI
Czechia	CZ	Latvia	LV	Spain	ES
Denmark	DK	Lithuania	LT	Sweden	SE
Estonia	EE	Luxembourg	LU	United Kingdom	GB
Finland	FI	Malta	MT	Euro area	EA
France	FR	Netherlands	NL	European Union	EU

3 Why do households' perceptions and expectations of inflation differ from the official measure of inflation?

3.1 Introduction

Households' perceived present rate of inflation and expected future rate of inflation differ substantially from the officially measured inflation rate. The average Harmonised Index of Consumer Prices (HICP), which is the official measure of consumer price inflation for the euro area, has increased on average 2% per year between 2003 and 2014. Households, however, perceived price increases to be consistently higher than the measured rate at an average of 10.7% per year, and they expected prices to continue to increase in the coming 12 months by 5.7%. There are large differences among households, but also across member states. In Finland, households perceived and expected inflation to be 3.8% and 3.1%, while the official rate was 1.9%. In some cases, these differences are substantially larger. For example, Italian households' perceived and expected inflation to be 16.0% and 5.3% respectively, while the official rate was 2.2% (see Chart 1 and Chart 2).

Several studies have tried to explain such differences between households' opinions about inflation and the official rate, which are commonly found in consumer surveys.[8] Jonung (1981) proposed that past experienced inflation matters for forming expectations for the future, e.g. households that experienced low rates in the past would tend to expect lower rates in the future.

[8] In this chapter 'opinions about inflation' and 'inflation opinions' are used to refer to both 'perceptions and expectations about inflation' and 'perceived and expected inflation'.

Chart 1: HICP inflation and households' perceived and expected inflation in selected member states in the European Union, 2003-2014 (%)

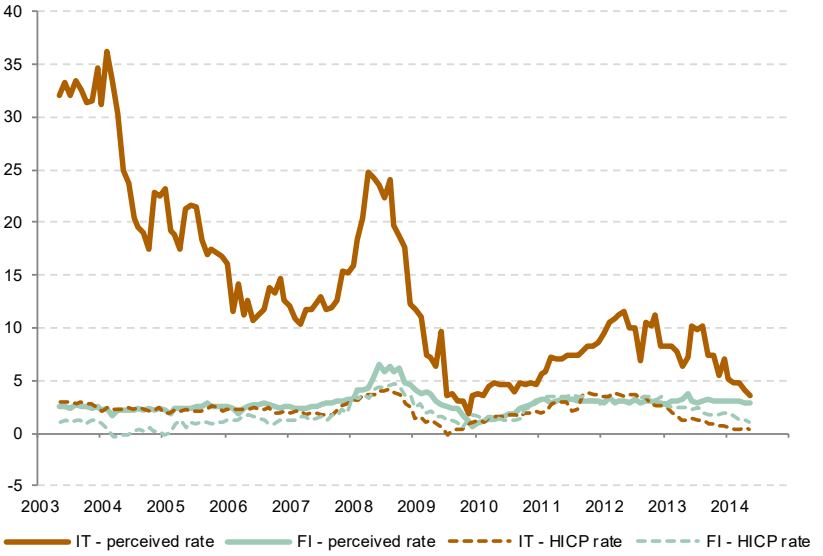
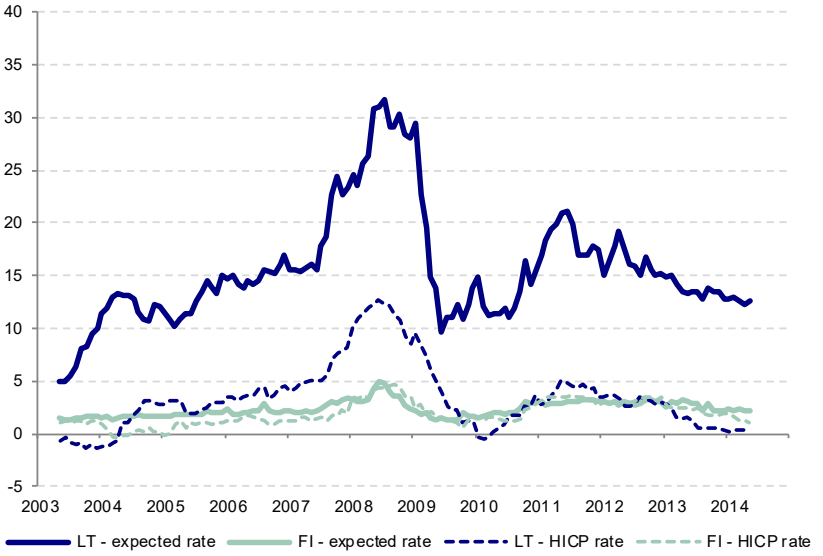


Chart 2: HICP inflation and households' perceived and expected inflation in selected member states in the European Union, 2003-2014 (%)



He also suggested that differences in purchasing patterns may explain significant differences between women and men. In a similar vein, Bryan and Venkatu (2001a) suggested that differences in consumption patterns may explain the differences between surveyed inflation expectations and the consumer price index in the US. In Europe, the euro-cash changeover also presents as a specific event that explains disparities between perceived and expected inflation and the HICP (see Ehrmann 2006).

This chapter provides an alternative explanation for why households' opinions about inflation deviate from the official inflation rate, which suggests that households' purchasing plans for big expenditure items matter when they form their opinions. The explanation rests on the theory of rational inattention, i.e. that it is costly to both gather and analyse data to form opinions on inflation developments, and that people pay attention to information according to their needs (Sims 2003; Reis 2006a). The hypothesis is that the more likely households are to spend a large sum of money, the stronger incentive they have to collect and process data to forecast inflation; this leads to their, producing better financial projections. The Harmonised Consumer Survey for the European Union is a unique database particularly useful for studying this hypothesis, with information on the households' views of past and future inflation. In addition, the survey contains information on households' likelihood to buy a new car, a house, and to make major home improvements. These economic activities may potentially induce strong incentives for people to form more precise expectations of inflation, or at least cause them to show an interest in general macroeconomic developments, thereby increasing the likelihood of becoming better informed.

The results show that stronger incentives to collect information on inflation induce households to produce perceived and expected inflation rates that more closely correspond to the officially measured rate of inflation (HICP), which may contain measurement errors, and that these incentives are stronger when inflation is higher. After correcting for outliers, households that say they are likely to spend a large sum of money on a car, a house, or home improvements perceive inflation to be about 0.8 of a percentage points lower than those not likely to spend a large sum of money. Similarly, such households expect inflation to be about 0.6 of a percentage point lower than those households that are not likely to make a large expenditure. In those months when the official inflation rate is above the sample median inflation, the respective differences increase to 1.9 and 1.6 percentage points. Thus, at times of high inflation, a substantial part of the difference between households' opinions about the inflation rate and the official rate can be explained, which is consistent with

the theory of rational inattention. At the same time, however, there is a significant bias that remains unexplained, leaving room for other explanations which are not tested in this thesis.

3.2 Background

Inflation expectations are more than of academic interest; the subject is an integral part of central bank policy (Blanchflower 2008; Côté 2015) and is consistently discussed by the governing boards of central banks (see, e.g., European Central Bank [ECB] 2016). According to the present approach to monetary policymaking, founded on inflation targeting, central banks should be forward-looking, framing their policies today on basis of forecasts of the future rate of inflation one to two years ahead. This approach requires access to reliable and frequently reported data on inflation expectations of the public. The ECB monitors inflation expectations in the euro area through several sources, including indicators derived from financial assets, consumer surveys, and surveys of professional forecasters (ECB 2003). Furthermore, expectations about the future course of the price level are important to decision-makers in all markets: for goods, labour, money, financial assets, and currencies. Decisions taken on these markets have an impact on the actual rate of inflation, nominal wage rates, interest rates, and exchange rates, as well as variables such as the rate of unemployment.

In standard models of unemployment, business cycle and inflation dynamics, the role of households' expectations is well established. However, how households form their expectations about the macroeconomy is still less understood (see Cavallo et al. 2014; Coibion and Gorodnichenko 2015). In practice it is difficult to generalise, as individuals are likely to form their expectations heterogeneously, using different information sets, relying on different models, and having different capacities for processing information (see Jonung 1984).

Measuring inflation expectations is far from an exact science. Such numbers are difficult to compile for the simple reason that inflation expectations are not directly measurable in a way that objective variables are (e.g. interest rates, monetary aggregates, rates of unemployment, consumer and producer prices, etc.). Expectations regarding the future behaviour of prices are held by individuals in their minds. To measure them in a representative way is therefore a major challenge for economists and for policymakers.

A straightforward way to measure the inflation expectations of the public is to ask people about them. In fact, a few surveys do exactly that. Examples of such surveys are the Swedish Household Survey, the University of Michigan Survey of Consumer Attitudes, and the Inflation Psychology Survey conducted by the Federal Reserve Bank of Cleveland in association with Ohio State University. Other countries such as Australia, New Zealand, India, and South Africa have also included explicit questions on inflation in their respective consumer surveys. More recently, the National Banks of Canada (Bank of Canada 2015) and Brazil (Campelo et al. 2014) have launched surveys of consumers' inflation expectations.

A potential problem with these surveys is that the questions asked concern variables that are difficult to assess or even understand. Inflation, for example, is a macro variable measuring the aggregate price level, but as households' consumption baskets do not necessarily correspond to the one used for calculating consumer price indices, the answers obtained on the surveys can differ substantially from the official inflation rates (see, e.g., Jonung 1981; Bryan and Venkatu 2001a, 2001b; Palmqvist and Strömberg 2004). This is often the case; typically surveys do show perceptions and expectations that are very different from the official rates.

Economists have put forth a few possible explanations as to why survey data are commonly higher than the official inflation estimates, but generally they fail to explain the differences (Bryan and Venkatu 2001b). These explanations refer to differences in respondents' shopping habits or in their shopping experience. For example, in terms of habits, one group of people may do more shopping than another, and therefore be in a better position to assess and forecast price developments. The shopping experience may also differ between groups of people because they buy different bundles of goods. One group may buy more durable goods (e.g. domestic appliances) and another may buy nondurable goods (e.g. food). In recent research, Das et al. 2019 show that the persistent upward bias in households' inflation opinions are also explained by price changes of different categories of consumption goods. They find that energy and food price inflation have a disproportionately large effect on households' opinions about inflation. Others suggest that people are simply irrational. None of these explanations are able to fully account for the observed difference between opinions about inflation and the official inflation rate; thus the question remains as to why this is the case.

3.3 Theory, empirical evidence, and hypothesis

Rational inattention offers a theoretical explanation for the difference between perceived and expected inflation and the official rate. The difference might be explained by the relatively weak incentives people face in their daily lives to gather information on inflation, i.e. most of the answers to the surveys would contain noisy signals. This is particularly true when member states of the European Union are experiencing low inflation, such as is occurring now and during a large part of the sample: it is not very important for people to have correct conjectures about future inflation on a daily basis. It is also especially true when information is costly, either in terms of money or processing capacity, and the cost must be weighed against an alternative use of available resources (Stigler 1961). On the other hand, there are instances when decisions must be made where inflation and interest rates could become important variables in people's lives, e.g. when a major investment is going to be undertaken, such as the purchase of a house.

These notions are embedded in the theory of rational inattention, which is motivated by the idea that individual households have limited capacity for processing information (Sims 2003). Sims uses information theory to develop a model where the information flow about macroeconomic variables is very low, and where people only devote a fraction of their information-processing capacity and attention to macroeconomic variables. A complementary approach is offered by Reis (2006a, 2006b), who assumes that it is costly for people to acquire, absorb, and process information in forming expectations and making decisions. In his framework, people rationally choose to update their information and their plans infrequently. Information becomes 'sticky', only gradually dissipating to the population. The model posits a rational behaviour by agents where they update information infrequently, as the optimal response to explicitly modelled costs of planning.

Carroll (2003, 2006) puts forward an alternative model, in which people do not have full understanding of the underlying macroeconomic construct. Instead, people are assumed to obtain their information from professional forecasters via news media or other secondary sources. However, each person is not observing all news at all times. Instead, people are assumed to absorb economic information from media sporadically, so that it may take considerable time before information spreads throughout the economy. This model provides a micro-foundation of how households form their expectations of macroeconomic variables — a framework Carroll refers to as 'epidemiological expectations'. Using the Michigan Survey of Consumer Attitudes, he shows

that the typical household updates its expectations about inflation roughly once a year and that they are forward looking when they do so.

Several recent papers have used Carroll's framework for studying the formation of inflation expectations. Lanne et al. (2009) propose and show that a significant proportion of the population rely on the past release of actual inflation, instead of basing their expectations on rational forward-looking forecasts produced by professional forecasters. Easaw and Golinelli (2012) extend Carroll's model to distinguish between purely forward-looking and 'stubborn' households, i.e. those that rely on their lagged one-year-ahead forecast. Easaw et al. (2013) employ an error-correction version of Carroll's model, relaxing the constraint that short- and long-term dynamics have the same absorption rate for the news. The results show that: (i) households absorb professional forecasts when forming expectations; (ii) households' expectations are determined by current inflation (or perceptions of current inflation); and (iii) current inflation signals are used to determine the future direction of inflation rates. Following the approach of Easaw et al., Campelo et al. (2014) studied the formation of inflation expectations in Brazil, adding the effects of households' opinions on the personal and general economic situation of that population.

The analysis in this study also follows those of Carroll (2003) and Easaw et al. (2013) that consider households' inattentive behaviour when forming their inflation expectations. The version of the model employed here considers the possibility that contemplating purchase of a car or a house, or making major home improvements, could determine how households perceive past inflation and shape expectations of future inflation. Households may also take into account various macroeconomic data. The estimated model therefore also considers the possibility that households consider the interest rate, the unemployment rate, and a measure of the output gap when forming their expectations. Households do not necessarily take these variables into account literally, but they may serve as proxies for information that individuals pick up through media and other channels. The output gap, for example, is not observable and rarely reported in regular media, but it may serve as a gauge for information on the current state of the business cycle.

The two main hypotheses (H1 and H2) tested in this chapter follow directly from the rational expectation literature:

H1: Households more likely to purchase a house or a car, or make significant home improvements, form less biased perceptions and expectations about inflation.

H2: The difference in perceived and expected inflation between households more and less likely to purchase a house or a car, or make significant home improvements, is less in times of low inflation.

Hypothesis 1 tests the implication that in certain circumstances in people's lives, some households are more likely to pay attention to economic news and events than others (e.g. when making decisions that may affect their wealth or income), and seeks to determine whether those with incentives to update their information are more attentive and likely to report less biased perceived and expected inflation rates.

Detailed questions in the Harmonised Consumer Survey for the EU on household purchasing plans of cars, houses, and home improvement make it possible to study these issues. It is conjectured that these durable consumption expenditures have a high probability of inducing the households to take on new loans or causing them to rebalance their portfolio, which increases the incentive to collect and process information on interest rates, risk premiums, and inflation rates, or just being more observant on macroeconomic news in general. Thus, the more likely the households are to spend large amounts of money, the closer their answers on inflation should be to the official rate, or more correct 'ex post'.

It is possible, however, that the purchase of durable goods such as a car and investments in real estate make people excessively attentive to price developments in these markets and cause them to form opinions about inflation based on these developments, instead of on general price developments. For example, if house prices are increasing faster than other asset prices or those of consumer goods, households more likely to purchase a house may consider inflation as higher than inattentive households.

Hypothesis 2 concerns the level of inflation in the economy, which changes the costs related to inflation that households face. When inflation is low, the costs of inflation and price volatility decline, making it less important for households to pay attention to price developments. To the extent households update their dataset less and pay less attention to price movements in general, the difference in perceived and expected inflation between attentive and inattentive households should be smaller. Furthermore, households may resort to low-cost strategies such as a rule of thumb approach, which in effect may lead households to produce better forecasts of inflation at times of low inflation, again reducing the difference between attentive and inattentive households. For example, a household assigning a low constant as its expectation of future inflation when inflation is low, and a high constant when

inflation is high, will on average produce better forecasts of inflation when inflation is low, as inflation volatility is lower at low inflation rates (Judson and Orphanides 1999). However, as for Hypothesis 1, if those households more likely to purchase a car or house, or make home improvements, are more influenced by price developments in these markets and they diverge from general price movements, the difference may increase.

One potential issue regarding this hypothesis is that of reverse causality. For example, if households think they are in a period of relatively low inflation, they may think that this is a good time to buy a car, a house, or make significant home improvements, i.e. inflation induce households to shift their spending in accordance with the level of inflation. If this is the case, the data should show a higher frequency of household being more likely to buy a house, a car or make significant home improvements. This is, however, not the case, and this type of reveres causality is not an issue for the results in this chapter. The frequency in terms of likelihood of spending a large sum of money is rather constant over time, the correlation with the inflation rate ranges from -0.18 to 0.05 and are not significantly different from zero. Households' investments in houses and purchases of cars rather seem to be driven by necessity, and less by intertemporal choices related to inflation.

3.4 Model

The analysis is based on a regression model with dummy variables, which allows for testing the hypothesis that households' purchasing plans for big expenditures such as a car, a house, or home improvements induce people to update their views on perceived and expected inflation and consider how these changes depend on the inflation environment.

Hypotheses 1 and 2 are tested using the regressions:

$$\pi_{h,t}^{Per} = \alpha + \beta_1 L_{h,t,1}^{Car} + \beta_1 L_{h,t,2}^{Car} + \beta_1 L_{h,t,3}^{Car} + \beta_1 L_{h,t,4}^{Car} + \varepsilon_{h,t} \quad (1)$$

$$\pi_{h,t}^{Exp} = \alpha + \beta_1 L_{h,t,1}^{Car} + \beta_1 L_{h,t,2}^{Car} + \beta_1 L_{h,t,3}^{Car} + \beta_1 L_{h,t,4}^{Car} + \varepsilon_{h,t} \quad (2)$$

where

$$L = \{1\ (very\ likely), 2\ (fairly\ likely), 3\ (not\ likely), 4\ (not\ at\ all\ likely)\}$$

Households' perceived ($\pi_{h,t}^{Per}$) and expected ($\pi_{h,t}^{Exp}$) inflation are regressed on an intercept (α) and a first set of dummy variables where households' answers

are categorised according to three questions in the Harmonised Consumer Survey for the EU on the likelihood to spend money. $L_{h,t,l}^{Car}$ is household h likelihood in month t for buying a car. There are four answers to the question, where l can take the value 1, 2, 3, or 4, representing the answer categories 'very likely', 'fairly likely', 'not likely', and 'not at all likely' to make the purchase. These variables take the value 1 if a respondent selected the respective answer category and zero otherwise. The intercept represents the average inflation opinion among households, and the β-coefficient represents any deviation from the average depending on households' likelihood to purchase a car.

Similarly, there are two pairs of regressions that include the other likelihood variables for buying a house or making major home improvements. The variables are labelled with superscripts House ($L_{h,t,l}^{House}$) and Renovation ($L_{h,t,l}^{Renovation}$), respectively.

Note, the regressions are not specified as deviations from measured inflation, because the focus is on the difference of opinions between different types of households, i.e. the comparison is not relative to a forecast error of zero. There are three reasons that motivate this specification. First, as Chapter 2 showed, perceived and expected inflation is excessively high in all countries. Thus, it is enough to show that some types of households have lower inflation opinions for the errors to be reduced. Second, this specification allows for using the full sample. By including the officially measured inflation rate on the left hand side of the regressions, which is the same for all households in any specific country and month, the sample is reduced to monthly average errors, loosing precision in the estimations. Third, the interpretation of the results is easier.

Hypothesis 1, whether households' purchasing plans matter when they form their opinions about perceived and expected inflation, is tested by comparing the differences between the coefficients for these 'likelihood' variables — the likelihood of spending money on a car, a house, or home improvements — and whether they are significantly different from zero (H_0: $\Delta\beta_{1,2} = \beta_1 - \beta_2 = 0$, $\Delta\beta_{2,3} = \beta_2 - \beta_3 = 0, \Delta\beta_{3,4} = \beta_3 - \beta_4 = 0$, in addition, $\Delta\beta_{2,4} = \beta_2 - \beta_4 = 0$ is tested). For the hypothesis to hold, coefficients of a higher likelihood of spending money should be lower than coefficients of a lower likelihood of spending money. If, for example, the mean for 'very likely' house buyers is lower than that of 'fairly likely' house buyers, this would be interpreted as a result in support of the hypothesis that spending patterns matter. Households that are more likely to be informed perceive and expect inflation to be closer to the official rate than households that are less likely to be informed.

Hypothesis 2, whether lower inflation matters when households with different purchasing plans form their opinions of inflation, is tested in the same way as for Hypothesis 1, with the addition of splitting the sample into two subsamples. The first subsample are months with higher inflation, and the second are months with lower inflation. The in-sample coefficients yet again test the first hypothesis, but comparing the coefficients from the two subsamples tests the second hypothesis (H_0: $\Delta\beta_{1,4}^{Low\ inflation} - \Delta\beta_{1,4}^{High\ inflation} = 0$).

To complete the specification, each regression is augmented with an additional three sets of variables controlling for socioeconomic differences among surveyed households, macroeconomic conditions, and remaining country differences. The full specification of the estimated equations is:

$$\pi_{h,t}^{Per} = \alpha + \sum_{l\in L}\beta_l L_{h,t,l}^{Car} + \sum_{i\in I}\gamma_i I_{h,t,i} + \sum_{i\in I}\gamma_w W_{h,t,w} + \sum_{e\in E}\gamma_e E_{h,t,e} + \\ + \sum_{a\in A}\gamma_a A_{h,t,a} + \gamma_s S_{h,t,s} + \sum_{m\in M}\gamma_m M_{h,t,m}^{n} + \sum_{c\in C}\gamma_c C_{h,c} + \varepsilon_{h,t} \quad (3)$$

$$\pi_{h,t}^{Exp} = \alpha + \sum_{l\in L}\beta_l L_{h,t,l}^{Car} + \sum_{i\in I}\gamma_i I_{h,t,i} + \sum_{i\in I}\gamma_w W_{h,t,w} + \sum_{e\in E}\gamma_e E_{h,t,e} + \\ + \sum_{a\in A}\gamma_a A_{h,t,a} + \gamma_s S_{h,t,s} + \sum_{m\in M}\gamma_m M_{h,t,m}^{n} + \sum_{c\in C}\gamma_c C_{h,c} + \varepsilon_{h,t} \quad (4)$$

Where $L = \{1,2,3,4\}$, $I = \{2,3,4\}$, $W = \{0,1,2\}$, $E = \{2,3\}$, $A = \{2,3,4\}$, $M = \{1\ (interest\ rate), 2\ (unemployment\ rate), 3\ (output\ gap)\}$, $C = \{All\ EU\ member\ states\ except\ AT\ and\ HU\}$

In total, regressions (3) and (4) contain 46 terms each. Following the intercept and the first set of four likelihood variables, the right-hand side of the equation also includes a second set of five variables controlling for socioeconomic differences among surveyed households. These variables control for previously identified differences in households' inflation opinions, e.g. that people with higher income perceive and expect inflation to be lower than people with lower income, and that opinions of women are different from those of men. Household characteristics include: income ($I_{h,t,i}$), where i = 2, 3 or 4 represent the second, third and fourth income quartile); work regime ($W_{h,t.w}$), where w = 0, 1 or 2 represent unemployed, part-time and full-time work); education ($E_{h,t.e}$), where e = 2 or 3 represent secondary and further education); age ($A_{h,t,a}$), where a = 2, 3, or 4 represent people of the ages 30–49, 50–64 and 65+, respectively); and sex ($S_{h,t,s}$) for women). These control variables are also defined as dummy variables, where a specific household characteristic is given the value 1 or else 0.

The third and final set of independent variables corresponds to macroeconomic information and country dummies. The macroeconomic variables ($M_{h,t,m}^{n}$, where m = 1, 2 and 3) are the interest rate, the unemployment rate,

and the output gap in the respective country (n) of the surveyed household. These information variables serve two purposes. First, this is information that households may take into account. However, they do not necessarily consider it literally, but it may serve as a proxy for data that individuals responding to the surveys pick up through media and other channels. Second, they account for time and country differences by gauging, for example, the business cycle. The regression also includes a set of country-specific dummy variables, identifying the member state of each household ($C_{h,c}$), where c is all EU member states except Austria and Hungary), controlling for any residual country specific effects. Austria is excluded so that the regression does not become overidentified, and Hungary is excluded because of the lack of data.

The regression does not include all the socioeconomic characteristics of a household nor does it include the answer category 'don't know' for the likelihood variables, in order that the equation does not become overidentified. The intercept thus measures the mean of a reference group of households that are not covered by the other characteristics, and can be interpreted as the average expected inflation rate for a reference person who is a male from Austria, between 16 and 29 years old, has an education comparable to primary school or less, does not take part in the labour market, has an income in the first quartile, and has not revealed his likelihood to spend a large sum of money. All other socioeconomic coefficients represent the deviations from the mean expected inflation of the reference group of households.

3.5 Data

The main part of the data used come from the Harmonised Consumer Survey for the European Union. National institutes in each of the 28 participating countries conduct their portion of the survey. The harmonised questionnaire contains questions on the economic situation of the household and the country where the household is located. It also contains information on the socioeconomic characteristics of the household: income, work regime, education, age, and sex.[9] Parallel with two qualitative questions on price

[9] The socioeconomic variables have the following characteristics: income (1st, 2nd, 3rd and 4th quartile), work regime (unemployed, part-time and full-time), education (primary, secondary, and further), age (16–29, 30–49, 50–64, and 65 and over), and sex (male and female). Note that income concerns the household and not the respondent, and that quartile ranges refer to each country-specific income distribution.

developments, two additional price questions were introduced in 2003 on an experimental basis. These questions ask respondents to quantify past and future inflation and give their responses in percentages. Furthermore, the questionnaire contains items that aim at establishing a household's likelihood to buy a new car, a house, and to make home improvements. For a more comprehensive description of the harmonised-EU-survey programme, see European Commission (1997, 2006, 2016).

The dependent variables for testing households' inattentive behaviour when forming expectations are the surveyed quantitative perceived and expected inflation. The quantitative price questions (labelled Q51 and Q61 in the harmonised questionnaire) are based on the individual responses to the qualitative price questions (labelled Q5 and Q6 in the harmonised questionnaire). The exact phrasing of these questions and their respective possible responses are as follows:

Q5 How do you think that consumer prices have developed over the last 12 months? They have: (1) risen a lot; (2) risen moderately; (3) risen slightly; (4) stayed about the same; (5) fallen; (N) don't know.

Q51 If question 5 was answered by 1, 2, 3, or 5: by how many percent do you think that consumer prices have gone up/down over the past 12 months? (Please give a single figure estimate): Consumer prices have increased by……,…% / decreased by……,…%.

Q6 By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will: (1) increase more rapidly; (2) increase at the same rate; (3) increase at a slower rate; (4) stay about the same; (5) fall; (N) don't know.

Q61 If question 6 was answered by 1, 2, 3, or 5: by how many percent do you expect consumer prices to go up/down in the next 12 months? (Please give a single figure estimate): Consumer prices will increase by……,…% / decrease by……,…%.

As the data contain numerous extreme values, they are trimmed. The amount and magnitude of the outliers differ across countries, which warrants using an approach that takes the distribution of replies into account.[10] The method applied in this chapter selects all responses that fall within the range of the 2nd to 3rd quartile, plus or minus 1.5 times the interquartile range of the 2nd to 3rd quartile. Thus, observations are considered outliers if they are larger than

[10] See Chapter 1 and Lindén (2006) and European Commission (2006) for a brief description.

q3 + 1.5(q3 – q2) or smaller than q2 - 1.5(q3 – q2), where q1 and q3 are the 25th and 75th percentiles, respectively. The value of 1.5 corresponds to approximately +/–2.7 standard deviations and a 99.3% coverage if the data are normally distributed. This truncation affects about 7% of all replies concerning inflation rates that are relevant for this chapter. Several trimming methods have been applied, and they do not influence the results in any material way, except the level of the average perceived or expected inflation rates.[11]

The main independent variables are three quarterly questions that are used to categorise households in terms of their likelihood to undertake a major investment in the coming months. The hypothesis is that these investment plans are reasons to form better inflation projections, in order to make better informed investment decisions. The higher the likelihood to invest or spend, the closer the answers to the price questions should be to the official rate of inflation. The formulation of these questions — labelled as questions 13, 14 and 15 in the harmonised questionnaire — and their respective possible responses are as follows:

Q13 How likely are you to buy a car over the next 12 months? (1) very likely; (2) fairly likely; (3) not likely; (4) not at all likely; (9) don't know.

Q14 Are you planning to buy or build a home over the next 12 months (to live in yourself, for a member of your family, as a holiday home, to let, etc.)? (1) very likely; (2) fairly likely; (3) not likely; (4) not at all likely; (9) don't know.

Q15 How likely are you to spend any large sum of money on home improvements or renovations over the next 12 months? (1) very likely; (2) fairly likely; (3) not likely; (4) not at all likely; (9) don't know.

These three questions on households' plans to spend money are only included in the survey programme on a quarterly basis, that is, in the months of January, April, July, and October. Thus, the corresponding inflation rates only amounts to one fourth of the total number of observations available. Furthermore, the answers to the questions are not equally distributed on to the different answer categories (1, 2, 3, 4, and 9). There are relatively few answers to the 'very likely' (6%), 'fairly likely' (7%), and 'not likely' (14%) alternatives, while the

[11] Several different trimming methods have been applied, e.g. truncating responses to an inflation rate to +/-100 percent and +/-50 percent. I have also tried the same trimming procedure as implemented in the University of Michigan Survey of Consumer Attitudes (see Curtin 1996). Responses above +95 percent or below -95 percent are truncated to +/-95 percent.

'not at all likely' (71%) alternative dominates completely. There are also big differences among countries (see Tables A3 to A8 in the Appendix).

Table 1 shows the complete breakdown of the share of households that answered both the questions on perceived and expected inflation and the questions on the likelihood of buying a car, a house, and making home improvements. The data cover the 11 years from July 2003 to April 2014 and include around 1 million individual observations from all 28 member states of the EU, except Hungary, for which data are not available. For the fully specified regressions 3 and 4, the sample is reduced and cover the period January 2004 to April 2014, because some member states had not yet introduced the quantitative questions into their survey. In general, households are more likely to do major home improvements (21%) than buying a car (12%), and they are least likely to buy a house (6%).

Table 1: Share (in percent) and number of households that answered both the questions on perceived and expected inflation and the questions on the likelihood of buying a car, a house, and making home improvements as distributed according to answer categories

	LIKELIHOOD VARIABLE					
	PERCEIVED INFLATION			EXPECTED INFLATION		
ANSWER	CAR	HOUSE	RENOVATION	CAR	HOUSE	RENOVATION
Very likely	4.7	2.2	9.1	4.8	2.3	9.3
Fairly likely	6.7	3.4	11.7	6.8	3.5	12.0
Not likely	15.9	8.0	17.5	15.9	7.9	17.6
Not at all likely	69.7	83.9	58.3	69.6	83.8	57.9
Don't know & n/a	3.0	2.5	3.4	2.9	2.5	3.2
No. of observations	1 020 193	1 020 193	1 020 193	995 918	995 918	995 918

As independent variables, the analysis also involves three macroeconomic variables, a short-term interest rate, the unemployment rate, and the output gap, that respondents may draw on to update their dataset and form their opinions on inflation or control for economic conditions. The interest rate used is the three-month interbank rate for each country or currency area (Datastream). The unemployment rate is the harmonised version published by Eurostat, the statistical office of the European Union. The output gaps come from AMECO, the annual macroeconomic database of the European Commission's Directorate General for Economic and Financial Affairs. The original main data source for the output gaps is Eurostat.

3.6 Empirical analysis and tests

This section presents the results of the two tests under the null hypothesis that households form perceptions and expectations in a rational inattentive manner.

3.6.1 Results of testing Hypothesis 1 — How households' spending patterns influence their perceptions and expectations about inflation

Table 2 presents the main results of the estimated parameters in the regression for the whole sample; it presents the results for a total of six regressions. There are two sets of equations: one for perceptions and one for expectations. Each set of regressions contains the three different likelihood variables (car, house, and renovation), respectively. In the table, each column represents the results from one regression. Since almost all coefficients are significant at conventional significance levels, only those coefficients that do not turn out to be significantly different from zero are marked with daggers (†).

The results and the inference in this chapter may suffer from what is called the p-value problem (see Lin et al. 2013). With very large samples, as in this case, p-values quickly go towards zero, which can lead to conclusions that are of no practical relevance, and increase the likelihood of false positives. To deal with this issue, the results are discussed not only in terms of statistical significance, but also in terms of 'economic significance'. In this chapter, economic significance means that the magnitude of the estimated coefficient or the difference between two coefficients is of economic relevance. For example, it implies that if the value of a coefficient — the average expected inflation rate — is so small that it does not really explain much of the dependent variable, it is not economically significant. It also means that the difference between two coefficients — the difference between two average expected inflation rates — is of a magnitude that does not make much difference in comparison with the level of expected inflation, it is not economically significant.

Note: the table does not present results as deviations from the officially measured inflation rate. On average, households perceive and expect inflation much higher than the official HICP rate (see Chapter 1 and Lindén, 2010). Thus, any kind of lowering of the average perceived or expected inflation rate can be interpreted as a move closer to the officially measured inflation rate.

Table 2: Estimated coefficients of the regressions where perceived and expected inflation rates are functions of one of the three likelihood variables (car, house, and renovation), income, work regime, education, and age (for the country coefficients see Table A2 in the Appendix)

		LIKELIHOOD VARIABLE					
		PERCEIVED INFLATION			EXPECTED INFLATION		
VARIABLE	ANSWER CAT.	CAR	HOUSE	RENOVATION	CAR	HOUSE	RENOVATION
Constant		5.56	5.19	5.71	3.82	3.70	3.94
Likelihood	(1) Very likely	1.12	1.13	1.00	0.33	0.26	0.32
	(2) Fairly likely	1.00	1.10	0.88	0.29	0.27	0.18
	(3) Not likely	0.75	0.30	0.75	0.24	-0.12	0.25
	(4) Not at all likely	1.82	1.89	1.80	0.96	0.85	0.89
Income	2nd quartile	0.20	0.19	0.21	0.20	0.20	0.21
	3rd quartile	-0.06	-0.09	-0.04†	0.10	0.08	0.11
	4th quartile	-0.64	-0.68	-0.63	-0.31	-0.35	-0.31
Work regime	Unemployed	0.67	0.69	0.66	0.58	0.60	0.57
	Part time	-0.05†	-0.05†	-0.05†	-0.11	-0.11	-0.10
	Full time	0.01†	0.02†	0.01†	0.01†	0.02†	0.01†
Education	Secondary	-0.38	-0.39	-0.37	-0.05	-0.06	-0.04
	Further	-1.09	-1.09	-1.06	-0.45	-0.45	-0.44
Age	30–49	0.56	0.56	0.59	0.53	0.53	0.56
	50–64	0.39	0.40	0.44	0.62	0.63	0.66
	65+	-0.06†	-0.03†	-0.01†	0.26	0.29	0.31
Sex	Female	0.90	0.91	0.91	0.43	0.44	0.44
Interest rate		0.62	0.62	0.63	0.37	0.37	0.37
Unempl. rate		-0.45	-0.45	-0.44	-0.32	-0.31	-0.31
Output gap		-0.13	-0.12	-0.12	0.05	0.05	0.05
R2		0.25	0.25	0.25	0.29	0.29	0.29
RMSE		8.91	8.91	8.91	7.50	7.50	7.50

Note: † represents insignificant coefficients. All other constants and coefficients are significant at the 5% level.

At first glance, incentives to collect information seem to matter partially when people form their views of inflation. All coefficients for the likelihood of buying a car or a house, or making home improvements, are significant. In general, the coefficients for the 'very likely' and the 'fairly likely' spenders are similar, although the 'fairly likely' spenders are somewhat lower than the 'very likely' spenders. The difference is at most 0.1 of a percentage point, which is economically insignificant. Households that are 'not at all likely' to spend a large sum of money have significantly higher perceived and expected inflation

rates, However, those that are 'not likely' to spend a large sum of money actually perceive and expect the lowest inflation rates.

Some clear patterns and differences emerge within the socioeconomic groupings, which are consistent with previous findings. For example, as reported in Lindén (2010), perceived and expected inflation fall as income rises. Perceptions fall by as much as 0.6 of a percentage point from the first quartile (25% – lowest income earners) to the fourth quartile (25% – highest income earners).[12] The difference for expectations is 0.3 of a percentage point. The same pattern can be observed for education: inflation rates fall as education increases. The difference between people with primary schooling and those with an education beyond secondary schooling is 1.1 percentage points for perceptions and 0.4 of a percentage point for expectations. Unemployed persons perceive and expect higher inflation than those with jobs (about 0.6 of a percentage point). The differences between the two other work regimes are less pronounced. Sex also matters: women have higher perceptions and expectations than men. The differences are 0.9 of a percentage point and 0.4 of a percentage point, respectively. For age, the pattern seems to be that perceived and expected inflation decrease with age, i.e. older persons perceive and expect slightly lower inflation rates than younger individuals. However, the youngest respondents, aged between 16 and 29, have the same perceptions as the oldest respondents and hold the lowest inflation expectations. For the country-specific coefficients, see Table A2 in the Appendix.

Calculating the differences between combinations of the likelihood coefficients generates a set of four restrictions that test the first hypothesis more formally. The first three restrictions test whether each adjacent pair of coefficients is equal. Following the numbering of the coefficients in Table 2, the restrictions are: (1) – (2) = 0, (2) – (3) = 0, and (3) – (4) = 0. If all restrictions are significantly negative, perceived and expected inflation increase as incentives to collect information and the motivation to form correct views of inflation decreases. As the 'not likely' coefficients are smaller than the 'not likely' coefficients, the fourth restriction tests whether the coefficients for the

[12] Note: in this regression setting some differences appear as compared to the unconditional averages for each socioeconomic grouping. For example, the coefficients in the regression indicates that respondents in the first income quartile perceive and predict lower inflation than those in the second and third, respectively. However, the simple averages for each income category show a clear falling trend from 8.8–7.2% for perceived inflation and 4.8–4.3% for expectations.

'not at all likely' households are equal to those of the 'fairly likely' households, i.e. whether (2) – (4) = 0. Table 3 summarises the results.

Table 3: Coefficient tests of likelihood variables car, house, and renovation

	LIKELIHOOD VARIABLES					
	PERCEIVED INFLATION			EXPECTED INFLATION		
TEST: H0	CAR	HOUSE	RENOVATION	CAR	HOUSE	RENOVATION
(1) - (2) = 0	0.12**	0.03	0.12***	0.04	0.00	0.14***
(2) - (3) = 0	0.24***	0.80***	0.13***	0.04	0.39***	-0.07**
(3) - (4) = 0	-1.07***	-1.59***	-1.05***	-0.72***	-0.97***	-0.63***
(2) - (4) = 0	-0.83***	-0.79***	-0.92***	-0.67***	-0.58***	-0.70***

Note: Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.

Thirteen of 24 tests of Hypothesis 1 reject the null hypothesis that households' purchasing plans do not matter, where the tests — $\Delta\beta_{1,2} = 0$, $\Delta\beta_{2,3} = 0$, $\Delta\beta_{3,4} = 0$ and $\Delta\beta_{2,4} = 0$ — are performed with t-tests and clustered standard errors. Thus, Table 3 shows partial statistical support for the first hypothesis that incentives to collect information matter when people form their views of inflation. The differences between the 'very likely' spenders and the 'fairly likely' spenders are small, slightly positive, and statistically significant in three of six cases (first row). Economically, however, there is no difference between the perceived and expected inflation among those households that are 'fairly likely' or 'very likely' to spend money. Most differences between the 'fairly likely' and the 'not likely' households are also positive and significant (row 2). Only one difference is negative: the combination of expected inflation and renovation. Although the differences are yet again economically small for the car and renovation categories, there is a significant difference for the house category, where not so likely house buyers actually perceive and expect lower inflation by 0.8 and 0.4 of a percentage point, respectively. This is clearly in conflict with the first hypothesis. The differences between the 'not likely' and the 'not at all likely' spenders are all negative and statistically and economically significant (row 3). The differences range from -0.6 of a percentage point to -1.6 percentage points. These negative differences are maintained between the 'fairly likely' spenders and the 'not at all likely spenders' (row 4).

To summarise, given the near equality between 'very likely' and 'fairly likely' car buyers and renovators, there is weak evidence that these households have more knowledge about past inflation, and are better at forming expectations of future inflation, than most households. However, households that say they are 'not likely' to buy a house are those that perceive and expect the lowest inflation rates, i.e. those closest to the officially measured inflation rate.

3.6.2 Results of testing Hypothesis 2 — How periods of high and low inflation influence households' perceived and expected inflation

The second hypothesis is tested by splitting the sample into two subsamples, one with all the monthly surveys when inflation is below the median inflation rate over the period January 2004 to April 2014, and a second with those months when inflation is above the median. In periods with low inflation the cost of inflation is low, and the incentives to consider the cost should be correspondingly low. The median inflation rate during the whole considered period is 2.1%, and there are 21 months of survey data in each subsample. The average inflation rate is 1.6% for the months in the low-inflation sample and it is 2.8% for the months in the high-inflation sample.

Table 4: Coefficient tests of likelihood variables car, house, and renovation in months of low and high inflation, respectively

	LIKELIHOOD VARIABLES					
LOW INFLATION	**PERCEIVED INFLATION**			**EXPECTED INFLATION**		
TEST: H0	**CAR**	**HOUSE**	**RENOVATION**	**CAR**	**HOUSE**	**RENOVATION**
(1) - (2) = 0	-0.29***	-0.20*	-0.91***	-0.34***	-0.30***	-0.89***
(2) - (3) = 0	-0.04	0.19**	-0.03	-0.23***	-0.25***	-0.19***
(3) - (4) = 0	-1.12***	-1.27***	-1.24***	-0.42***	-0.54***	-0.26***
(2) - (4) = 0	-1.45***	-1.28***	-2.18***	-0.98***	-1.10***	-1.34***
HIGH INFLATION	**PERCEIVED INFLATION**			**EXPECTED INFLATION**		
TEST: H0	**CAR**	**HOUSE**	**RENOVATION**	**CAR**	**HOUSE**	**RENOVATION**
(1) - (2) = 0	-0.68***	-0.47***	-1.12***	-0.70***	-0.48***	-1.14***
(2) - (3) = 0	-0.40***	-0.67***	-0.24***	-0.54***	-0.54***	-0.34***
(3) - (4) = 0	-0.68***	-0.45***	-0.91***	-0.35***	-0.37***	-0.22***
(2) - (4) = 0	-1.76***	-1.59***	-2.27***	-1.59***	-1.39***	-1.71***

Note: Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.

Tests of Hypothesis 2 reject the null hypothesis that the difference in inflation opinions between households more or less likely to spend money are equal, where the tests are $\Delta\beta_{1,4}^{Low\ inflation} - \Delta\beta_{1,4}^{High\ inflation} = 0$ for the respective spending item (car, house, and renovation) and inflation environment (low or high). Table 4 shows strong support for both the hypothesis that households' purchasing plans matter when people form their views of inflation and that the difference in inflation opinions between households more and less likely to spend money are less when inflation is low. Perceived and expected inflation declines as the more likely the households are to spend a large sum of money. The only exception is for perceived inflation in the low-inflation sample, where households that say that they are 'not likely' to buy a house perceive inflation

to be lower than those households that say they are 'fairly likely' to buy a house. Furthermore, the decline in perceived and expected inflation is higher in months of higher inflation, i.e. when the cost of inflation is higher (the last row in each panel of Table 4). For perceived inflation, the differences between the low-inflation sample and the high inflation sample ranges between 0.1–0.3 of a percentage point, and for expectations they range between 0.3–0.6 of a percentage point. These differences are statistically significant except for one, the 0.1 percentage point difference for perceived inflation and households that are likely to do a major renovation.

3.6.3 Controlling for income effect

A number of studies have analysed the relationship between income and education and, on average, one would expect higher levels of education to be associated with higher incomes (see, e.g., Becker 1962; Burgess 2016). Although the correlation between income and education is quite low in this case, regressing income on education and a constant results in a positive slope coefficient that is statistically significant. The coefficient is very low, and the economic significance is almost negligible. Basically, a move from the category labelled 'primary education' to the category labelled 'further education' just implies a rise in income of a small fraction of an income quartile, which is the measure of income. Nevertheless, it could be important to control for any possible existence of co-linearity between education and income.

For this purpose, the sample is divided into four new subsets according to the four income categories. Furthermore, the answers to the likelihood variables for spending large sums of money are regrouped into two new aggregated groups. The 'very likely' and the 'fairly likely' categories are placed together in a new group called 'likely', and the 'not at all likely' are merged with the 'not likely'. This is done in order to maintain reasonable sample sizes and, as the previous results show, the loss of information by doing so is small. Thus, in this case, two sets of regression equations (perceptions and expectations) are estimated for each combination of income class and likelihood variable, resulting in a total of 12 new regressions.

Education is more or less linearly and negatively related to perceived and expected inflation. Education is therefore included as an independent variable in its own right, without first making dummy variables. Also, the sex dummy is kept in the estimation. In the estimation, the coefficients for education and sex are expected to be significantly negative and positive, respectively. The

variables work regime and age are left out because these two variables turn out to be not significant in several of the estimated equations, which is probably related to the division of the sample into four subsets.

The estimates in Table 5, where perceived inflation is the dependent variable, show that the coefficients are in all cases significantly different from zero. More importantly, the coefficients for the groups of people likely to buy a car or house, or spend a large sum of money on home improvements, are smaller than for those that are not likely to spend a large sum of money. Furthermore, both education and sex are strongly significant variables, showing that people with higher education perceive inflation to be lower than those who are less educated, and women perceive inflation to be higher than men.

Table 5: Estimated regression coefficients by income for perceived inflation rates as a function of one of the three likelihood variables (car, house, and renovation), education, and sex

		INDEPENDENT VARIABLES				
			ANSWER CATEGORY			
LIKELIHOOD VARIABLE	INCOME CLASS	CONSTANT[A]	(1) LIKELY	(2) NOT LIKELY	EDUCATION[A]	SEX[A]
Car	I	5.77	1.08***	2.08***	-0.22	0.68
	II	5.78	0.91***	1.65***	-0.40	0.95
	III	6.62	0.73***	1.19***	-0.48	0.98
	IV	5.70	1.24***	1.71***	-0.57	0.98
House	I	5.44	1.35***	2.37***	-0.22	0.69
	II	5.47	1.24***	1.90***	-0.40	0.96
	III	6.44	0.76***	1.32***	-0.48	0.98
	IV	5.64	1.13***	1.72***	-0.57	0.99
Renovation	I	6.02	1.14***	1.94***	-0.22	0.69
	II	6.05	0.79***	1.49***	-0.39	0.95
	III	6.84	0.55***	1.05***	-0.48	0.98
	IV	5.82	1.17***	1.70***	-0.57	0.99

Note: Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.
A) All constants and the coefficients for education and sex are significant at the 1% level.

The results for expectations are very similar to those of perceptions. Table 6 shows that most of the estimated coefficients for the likelihood variables are

Table 6: Estimated regression coefficients by income for expected inflation rates as a function of one of the three likelihood variables (car, house, and renovation), education, and sex

		INDEPENDENT VARIABLES				
		ANSWER CATEGORY				
LIKELIHOOD VARIABLE	INCOME CLASS	CONSTANT[A]	(1) LIKELY	(2) NOT LIKELY	EDUCATION[A]	SEX[A]
Car	I	4.00	0.42***	1.11***	-0.11	0.35
	II	4.42	0.17	0.82***	-0.24	0.46
	III	4.54	0.15	0.58***	-0.24	0.47
	IV	4.20	0.29***	0.83***	-0.29	0.56
House	I	3.79	0.40**	1.29***	-0.11	0.36
	II	4.31	0.20	0.87***	-0.24	0.47
	III	4.60	-0.02	0.49***	-0.24	0.48
	IV	4.28	0.23**	0.67***	-0.28	0.57
Renovation	I	4.07	0.41***	1.15***	-0.10	0.35
	II	4.74	-0.03	0.60***	-0.23	0.47
	III	4.72	0.07	0.47***	-0.24	0.48
	IV	4.36	0.32***	0.71***	-0.28	0.57

Note: Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.
A) All constants and the coefficients for education and sex are significant at the 1% level.

significantly different from zero, and that likely buyers of cars and houses, as well as home improvers, have lower expectations of inflation than those not likely to spend large sums of money. Furthermore, comparing the coefficients for the two variables 'likely' and 'not likely' yet again tests the main hypothesis, where Table 7 presents the tests of whether the differences between the two likelihood coefficients are equal or not. The asterisks mark the statistically significant differences, and the table shows that all differences are highly significant.

Table 7: Coefficient tests by income of likelihood variables car, house, and renovation

	LIKELIHOOD VARIABLES					
	PERCEIVED INFLATION			EXPECTED INFLATION		
TEST: (1) - (2) = 0	CAR	HOUSE	RENOVATION	CAR	HOUSE	RENOVATION
I	-1.00***	-1.02***	-0.80***	-0.68***	-0.89***	-0.74***
II	-0.74***	-0.66***	-0.70***	-0.65***	-0.68***	-0.63***
III	-0.46***	-0.57***	-0.50***	-0.43***	-0.51***	-0.40***
IV	-0.47***	-0.59***	-0.53***	-0.54***	-0.44***	-0.39***

Note: Asterisks represent a significance level of: *** = 1%, ** = 5%, and * = 10%.

All tests of Hypothesis 1 reject the null hypothesis that households' purchasing plans do not matter, but the results in Table 7 point to an outcome contingent on the level of income. It seems that the differences between the coefficients are larger for the lower income groups, especially for perceptions. For income

class I the differences are the greatest, ranging from 1–0.7 of a percentage point. They are slightly smaller in income class II, and range between 0.7–0.6 of a percentage point. In the two highest income categories, the differences are very similar and smaller, i.e. middle- to high-income earners hold more similar perceptions and expectations. Nevertheless, there is a significant difference between those that are more or less likely to spend a large sum of money.

The overall conclusion is that activities such as buying a car or a house, or spending a large sum of money on home improvement, do in fact provide people with incentives to collect and process information on inflation. Furthermore, these activities induce people to form perceptions and expectations that are closer to the official measure of inflation than otherwise is the case.

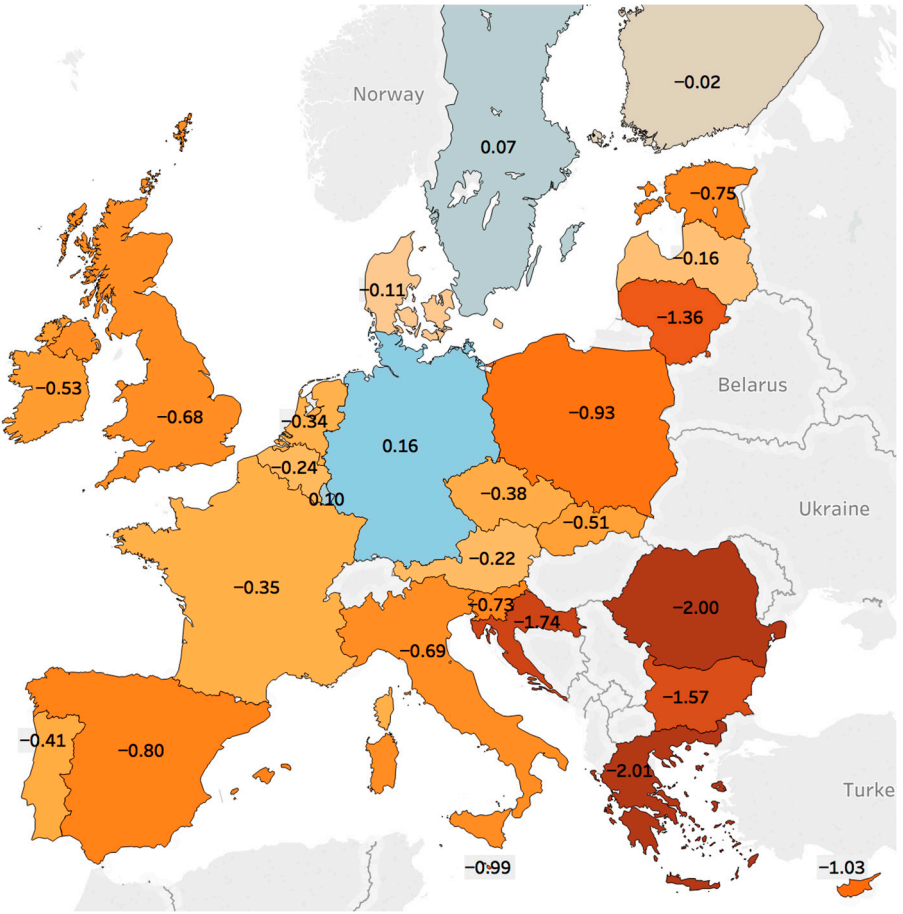
3.7 Country differences

At the country level, most tests of Hypothesis 1 reject the null hypothesis that households' purchasing plans do not matter, but the results differ significantly across countries. To summarise the results, Figure 1 and Figure 2 show the average differences in perceived and expected inflation between those households that are 'likely' and 'not likely' to spend a large sum of money on either a car, a house, or home improvement, i.e. the results are aggregated across the three different purchasing plans covered by the survey.[13] In total, 81 country-specific tests are performed, three for each member state. Seventy test statistics are negative for both perceived and expected inflation and, at the 5% significance level, 58 and 51 of them are significantly different from zero, respectively. Only five (perceived) and six (expected) of the test statistics are significantly positive. For the complete set of regression coefficients and tests, see Table A9 to Table A15 in the Appendix.

There are no significant differences comparing the results for perceived and expected inflation, and the differences in inflation opinions between the 'likely' and the 'not likely' spenders range between -2.3 and 0.2 percentage

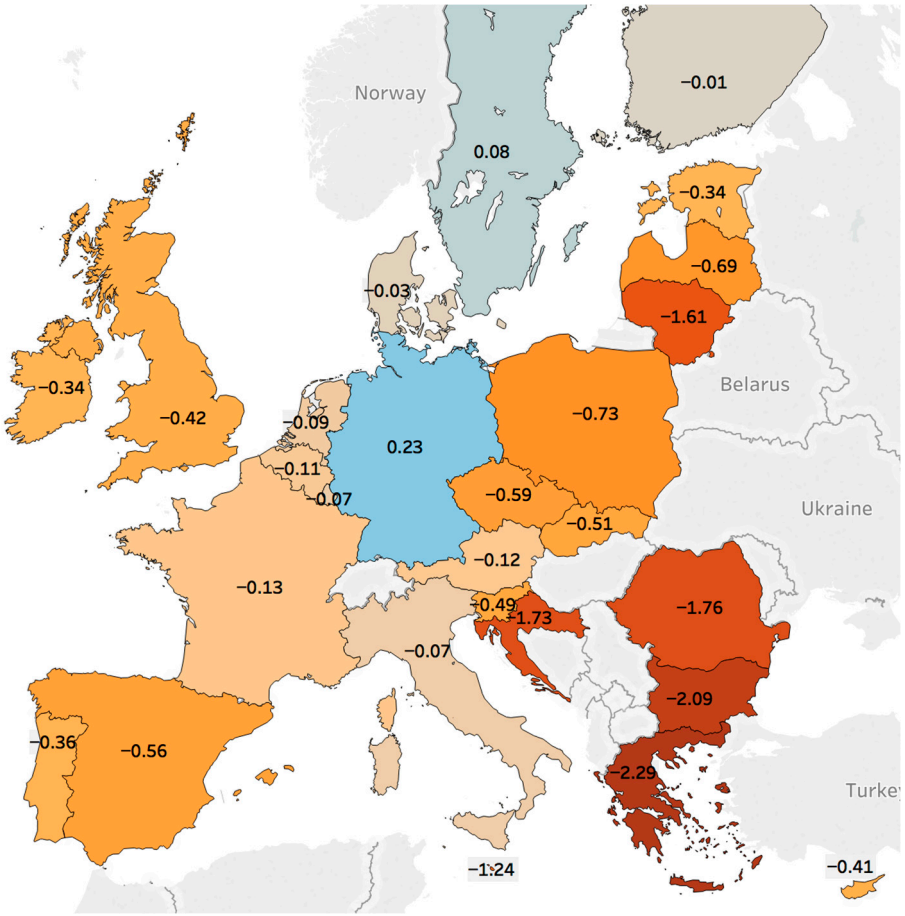
[13] As in the previous section, the four answer categories ('very likely', 'fairly likely', 'not at all likely', and 'not likely') are aggregated into two ('likely' and 'not likely').

Figure 1: Average of test coefficients for perceived inflation and likelihood variables car, house, and renovation by country



points. Central and eastern EU countries show larger differences between the 'likely' and 'not likely' spenders, while in Northern EU countries there is basically no difference. For perceived inflation, about 19 countries show significant differences between those who say they are 'likely' and those who say they are 'not likely' spenders at conventional significance levels, which increases to 21 countries at the 10% level. For expected inflation, slightly fewer countries show significant differences, i.e. 18 at the 5% level and 20 at the 10% level.

Figure 2: Average of test coefficients for expected inflation and likelihood variables car, house, and renovation by country



In line with the second hypothesis, the level of inflation explains a significant part of the cross-country differences. In accordance with the hypothesis, in countries that have experienced higher inflation rates, the differences in households' inflation opinions between the 'likely' and the 'not likely' spenders are higher. In a regression with the differences in inflation opinions between the two groups as the dependent variable and the countries' mean inflation rate during the considered sample period as the independent variable, the level of inflation explains about 30% of the country variation. Similarly, the differences in inflation volatility also explains the cross-country differences in inflation opinions, although less so.

3.8 Concluding discussion

Several studies have tried to explain the differences between households' opinions about inflation and the official rate, commonly found in consumer surveys. The purpose of this chapter is to provide an alternative explanation to those of previous studies, resting on the theory of rational inattention. The idea is that households' purchasing plans for big expenditure items matter for providing incentives for households to gather and analyse information that comes at a cost. The hypothesis is that the more likely households are to spend a large sum of money, the stronger incentives they have to collect information about inflation, as part of getting a view of where the economy is going. Therefore, they would be able to produce better projections in the sense that they move closer to the official inflation rate. In addition, and following directly from the theory of rational inattention, the incentive to collect and process such information on inflation is lower when inflation in the economy is lower.

The Harmonised Consumer Survey for the European Union is a unique database, with information on the households' views of past and future inflation that allows for studying these questions. It also contains information on households' likelihood to buy a new car, a house, and making major home improvements. These economic activities may potentially induce strong incentives for households to form more precise expectations of inflation, or at least show an interest in general macroeconomic developments, which increases the likelihood of becoming better informed. The information on households' purchasing plans is used as a device to group households in terms of how strong incentives they may have to collect and analyse costly information about inflation.

The main results show that stronger incentives to collect information on inflation induce households to produce perceived and expected inflation rates that more closely correspond to the official rate of inflation. After correcting for outliers, households who say they are likely to spend a large sum of money on a car, a house, or home improvements perceive inflation to be 0.8–0.9 of a percentage point lower than those that are not likely to spend a large sum of money. Similarly, households expect inflation to be 0.6–0.7 of a percentage point lower than those that are not likely to spend a large sum of money. Overall perceived and expected inflation in the sample are respectively 7.8% and 4.5%, while the official inflation rate was 2.2%. So, even if perceived and expected inflation moves closer to the official rate, they are both still much higher than the official rate.

A second result is that the incentives to collect and analyse information is stronger when inflation is higher. In those months when inflation is higher than the median official inflation rate in the considered sample, households who say they are likely to spend a large sum of money on a car, a house, or home improvements perceive inflation to be 1.9 percentage points lower than those not likely to spend a large sum of money. Similarly, households expect inflation to be 1.6 percentage points lower than those not likely to spend a large sum of money. In this case, the theory of rational inattentive consumers can explain a substantial part of the difference between households' inflation opinions and the official HICP rate.

3.9 References

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3.10 Appendix

Table A1: Names and abbreviations of countries in the European Union

COUNTRY	ABBREVIATION	COUNTRY	ABBREVIATION	COUNTRY	ABBREVIATION
Austria	AT	Germany	DE	Poland	PL
Belgium	BE	Greece	GR	Portugal	PT
Bulgaria	BG	Hungary	HU	Romania	RO
Croatia	HR	Ireland	IE	Slovakia	SK
Cyprus	CY	Italy	IT	Slovenia	SI
Czechia	CZ	Latvia	LV	Spain	ES
Denmark	DK	Lithuania	LT	Sweden	SE
Estonia	EE	Luxembourg	LU	United Kingdom	GB
Finland	FI	Malta	MT	Euro area	EA
France	FR	Netherlands	NL	European Union	EU

Table A2: Estimated coefficients of the regressions where perceived and expected inflation rates are functions of one of the three likelihood variables (car, house and renovation), income, work regime, education, and age (Table 2 continued).

	LIKELIHOOD VARIABLES					
	PERCEIVED INFLATION			EXPECTED INFLATION		
COUNTRY	CAR	HOUSE	RENOVATION	CAR	HOUSE	RENOVATION
BE	1.75	1.98	1.71	1.99	1.99	1.97
BG	13.41	13.60	13.32	13.57	13.55	13.50
HR	12.51	12.86	12.38	12.58	12.59	12.50
CY	6.94	7.19	6.77	7.16	7.16	7.04
CZ	-0.27	-0.15	-0.24	-0.17	-0.17	-0.16
DK	-2.79	-2.58	-2.96	-2.62	-2.64	-2.72
EE	3.98	4.25	4.06	4.24	4.27	4.28
FI	-2.20	-2.03	-2.38	-1.97	-2.00	-2.07
FR	0.66	0.89	0.54	0.89	0.89	0.82
DE	-0.89	-0.83	-0.89	-0.85	-0.86	-0.90
GR	10.34	10.63	10.16	10.49	10.51	10.36
IE	1.85	1.93	1.64	1.94	1.91	1.79
IT	7.59	7.82	7.39	7.80	7.80	7.69
LV	11.17	11.34	11.09	11.21	11.15	11.16
LT	11.71	11.87	11.59	11.85	11.85	11.76
LU	-1.37	-1.15	-1.40	-1.14	-1.13	-1.15
MT	0.85	1.11	0.81	1.11	1.11	1.08
NL	-0.73	-0.65	-1.00	-0.62	-0.68	-0.72
PL	7.55	7.69	7.53	7.59	7.58	7.55
PT	0.27	0.63	0.11†	0.35	0.37	0.24
RO	8.25	8.55	8.20	8.35	8.37	8.28
SK	5.74	6.02	5.71	5.87	5.89	5.81
SI	3.19	3.36	3.13	3.36	3.37	3.33
ES	9.63	9.98	9.41	9.66	9.67	9.52
SE	-3.37	-3.09	-3.42	-3.22	-3.21	-3.27
GB	1.27	1.39	1.14	1.33	1.34	1.24

Note: † represents insignificant coefficients. All other constants and coefficients are significant at the 5% level.

Table A3a: Share (in percent) and number of households that answered both the question on perceived inflation and the question on the likelihood of buying a car as distributed according to answer categories.

	ANSWER CATEGORIES ON LIKELIHOOD OF BUYING A CAR		
COUNTRY	VERY LIKELY (%)	FAIRLY LIKELY (%)	NOT LIKELY (%)
AT	8.0	5.7	28.6
BE	5.5	5.6	6.5
BG	1.2	5.4	12.1
HR	1.2	4.0	21.5
CY	9.9	6.9	6.8
CZ	5.3	5.3	19.3
DK	7.7	10.3	11.9
EE	2.8	7.9	8.0
FI	10.5	9.7	7.2
FR	6.5	7.7	7.8
DE	2.0	7.0	24.1
GR	3.8	4.1	15.1
HU	-	-	-
IE	10.3	11.5	17.0
IT	2.2	5.1	8.0
LV	3.3	12.1	23.1
LT	1.0	4.5	15.5
LU	9.9	8.1	5.9
MT	2.0	1.9	4.2
NL	13.2	9.2	15.8
PL	1.7	6.6	23.2
PT	0.8	2.6	23.1
RO	2.9	8.0	10.9
SK	1.1	6.0	16.9
SI	4.6	6.8	13.0
ES	1.5	5.5	24.9
SE	10.8	11.3	12.4
GB	6.5	8.1	20.6
EA	4.9	6.2	15.7
EU	4.7	6.7	15.9

Note: For country names and abbreviations see Table A1.

Table A3b: Share (in percent) and number of households that answered both the question on perceived inflation and the question on the likelihood of buying a car as distributed according to answer categories.

	ANSWER CATEGORIES ON LIKELIHOOD OF BUYING A CAR		
COUNTRY	NOT AT ALL LIKELY (%)	DON'T KNOW (%)	NO OF RESP.
AT	57.5	0.2	57 094
BE	82.0	0.4	44 718
BG	72.8	8.5	31 932
HR	71.3	2.0	29 393
CY	71.7	4.7	25 822
CZ	69.4	0.7	30 444
DK	69.9	0.2	34 606
EE	80.8	0.4	3 535
FI	71.9	0.7	52 641
FR	77.9	0.1	37 589
DE	62.5	4.4	67 602
GR	75.2	1.9	53 066
HU	-	-	-
IE	52.8	8.4	30 804
IT	84.3	0.3	59 167
LV	56.6	4.9	36 102
LT	77.8	1.2	50 468
LU	75.7	0.4	18 023
MT	89.9	2.0	35 742
NL	60.3	1.5	11 941
PL	65.4	3.0	33 741
PT	73.0	0.6	33 810
RO	72.4	5.7	35 158
SK	75.2	0.7	43 800
SI	75.6	0.1	25 837
ES	67.0	1.1	64 425
SE	59.8	5.8	51 944
GB	58.0	6.8	63 740
EA	71.6	1.6	600 288
EU	69.7	3.0	1 020 193

Note: For country names and abbreviations see Table A1.

Table A4a: Share (in percent) and number of households that answered both the question on expected inflation and the question on the likelihood of buying a car as distributed according to answer categories.

	ANSWER CATEGORIES ON LIKELIHOOD OF BUYING A CAR		
COUNTRY	VERY LIKELY (%)	FAIRLY LIKELY (%)	NOT LIKELY (%)
AT	7.9	5.7	28.6
BE	5.3	5.6	6.5
BG	1.2	5.6	12.4
HR	1.2	4.1	21.8
CY	9.9	7.1	6.6
CZ	5.5	5.4	19.8
DK	7.6	10.3	12.0
EE	3.8	7.5	8.9
FI	10.5	9.7	7.1
FR	6.1	7.6	7.6
DE	2.1	7.0	24.2
GR	4.1	4.3	16.0
HU	-	-	-
IE	9.9	11.2	17.5
IT	2.1	5.0	7.6
LV	3.5	12.4	23.4
LT	1.0	4.5	15.6
LU	10.0	8.1	5.9
MT	1.9	1.9	4.3
NL	12.9	9.6	15.9
PL	1.9	6.6	23.3
PT	0.8	2.5	22.7
RO	3.0	8.2	11.0
SK	1.2	6.1	16.9
SI	4.5	6.8	13.0
ES	1.6	5.7	25.3
SE	10.7	11.2	12.4
GB	6.5	8.2	20.6
EA	5.0	6.3	15.8
EU	4.8	6.8	15.9

Note: For country names and abbreviations see Table A1.

Table A4b: Share (in percent) and number of households that answered both the question on expected inflation and the question on the likelihood of buying a car as distributed according to answer categories.

	ANSWER CATEGORIES ON LIKELIHOOD OF BUYING A CAR		
COUNTRY	NOT AT ALL LIKELY (%)	DON'T KNOW (%)	NO OF RESP.
AT	57.6	0.2	56 601
BE	82.2	0.4	44 676
BG	72.5	8.3	28 920
HR	71.0	2.0	27 612
CY	72.3	4.1	22 802
CZ	68.6	0.7	29 481
DK	69.9	0.2	34 129
EE	76.3	3.5	18 904
FI	72.1	0.6	52 850
FR	78.5	0.1	39 136
DE	62.4	4.4	66 714
GR	73.7	1.9	48 843
HU	-	-	-
IE	53.5	7.9	29 182
IT	85.0	0.3	53 531
LV	56.1	4.6	34 003
LT	77.7	1.2	49 623
LU	75.7	0.4	17 677
MT	90.8	1.1	28 443
NL	60.2	1.4	12 509
PL	65.3	2.9	31 151
PT	73.4	0.6	32 916
RO	72.2	5.5	32 587
SK	75.2	0.7	42 948
SI	75.6	0.1	25 684
ES	66.4	1.0	57 621
SE	60.1	5.6	52 411
GB	58.0	6.7	64 640
EA	71.4	1.5	574 914
EU	69.6	2.9	995 918

Note: For country names and abbreviations see Table A1.

Table A5a: Share (in percent) and number of households that answered both the question on perceived inflation and the question on the likelihood of buying a house as distributed according to answer categories

	ANSWER CATEGORIES ON LIKELIHOOD OF BUYING A HOUSE		
COUNTRY	VERY LIKELY (%)	FAIRLY LIKELY (%)	NOT LIKELY (%)
AT	2.8	4.0	3.5
BE	2.9	3.0	2.5
BG	0.4	1.4	6.6
HR	0.7	2.8	20.0
CY	4.7	4.2	5.9
CZ	2.5	2.6	4.8
DK	4.0	4.4	6.5
EE	2.7	3.9	4.9
FI	4.1	4.6	1.8
FR	4.3	3.7	3.4
DE	0.7	3.3	5.7
GR	1.5	2.7	11.4
HU	-	-	-
IE	3.2	3.6	4.8
IT	0.8	1.7	4.4
LV	1.3	5.2	15.3
LT	0.9	1.6	5.0
LU	6.4	4.8	2.4
MT	1.2	1.3	3.1
NL	3.3	4.7	5.1
PL	1.1	3.1	9.0
PT	1.1	1.8	19.6
RO	1.7	4.3	9.1
SK	1.1	3.1	12.3
SI	3.8	3.4	2.7
ES	1.0	2.8	22.4
SE	3.9	7.0	10.6
GB	3.2	4.3	5.0
EA	2.2	3.2	7.7
EU	2.2	3.4	8.0

Note: For country names and abbreviations see Table A1.

Table A5b: Share (in percent) and number of households that answered both the question on perceived inflation and the question on the likelihood of buying a house as distributed according to answer categories

	ANSWER CATEGORIES ON LIKELIHOOD OF BUYING A HOUSE		
COUNTRY	NOT AT ALL LIKELY (%)	DON'T KNOW (%)	NO OF RESP.
AT	89.6	0.0	57 094
BE	91.3	0.3	44 718
BG	85.1	6.5	31 932
HR	75.1	1.4	29 393
CY	80.7	4.6	25 822
CZ	89.6	0.4	30 444
DK	85.0	0.1	34 606
EE	87.6	0.9	3 535
FI	89.2	0.2	52 641
FR	88.6	0.1	37 589
DE	87.6	2.7	67 602
GR	82.0	2.4	53 066
HU	-	-	-
IE	80.1	8.2	30 804
IT	92.9	0.2	59 167
LV	76.2	2.0	36 102
LT	92.3	0.2	50 468
LU	86.1	0.3	18 023
MT	93.4	1.0	35 742
NL	86.0	0.7	11 941
PL	85.3	1.5	33 741
PT	77.2	0.4	33 810
RO	79.3	5.7	35 158
SK	82.9	0.6	43 800
SI	90.0	0.0	25 837
ES	73.0	0.8	64 425
SE	71.4	7.1	51 944
GB	80.9	6.6	63 740
EA	85.7	1.2	600 288
EU	83.9	2.5	1 020 193

Note: For country names and abbreviations see Table A1.

Table A6a: Share (in percent) and number of households that answered both the question on expected inflation and the question on the likelihood of buying a house as distributed according to answer categories

	ANSWER CATEGORIES ON LIKELIHOOD OF BUYING HOUSE		
COUNTRY	VERY LIKELY (%)	FAIRLY LIKELY (%)	NOT LIKELY (%)
AT	2.8	4.0	3.5
BE	2.8	3.0	2.4
BG	0.4	1.5	6.8
HR	0.8	2.8	20.2
CY	4.8	4.3	5.4
CZ	2.6	2.8	4.9
DK	4.0	4.3	6.5
EE	2.4	4.0	5.2
FI	4.1	4.7	1.9
FR	4.0	3.6	3.4
DE	0.7	3.4	5.7
GR	1.6	2.8	12.2
HU	-	-	-
IE	3.1	3.4	4.9
IT	0.8	1.6	4.4
LV	1.4	5.5	15.5
LT	0.9	1.6	5.0
LU	6.4	4.9	2.4
MT	1.3	1.4	3.3
NL	3.4	4.8	5.0
PL	1.1	3.2	9.1
PT	1.1	1.7	19.6
RO	1.8	4.4	9.2
SK	1.2	3.1	12.2
SI	3.9	3.4	2.7
ES	1.0	2.9	23.0
SE	3.9	7.0	10.5
GB	3.2	4.3	4.9
EA	2.3	3.2	7.7
EU	2.3	3.5	7.9

Note: For country names and abbreviations see Table A1.

Table A6b: Share (in percent) and number of households that answered both the question on expected inflation and the question on the likelihood of buying a house as distributed according to answer categories

	ANSWER CATEGORIES ON LIKELIHOOD OF BUYING HOUSE		
COUNTRY	NOT AT ALL LIKELY (%)	DON'T KNOW (%)	NO OF RESP.
AT	89.6	0.1	56 601
BE	91.6	0.2	44 676
BG	84.8	6.5	28 920
HR	74.9	1.4	27 612
CY	81.6	3.9	22 802
CZ	89.3	0.4	29 481
DK	85.1	0.1	34 129
EE	84.6	3.8	18 904
FI	89.2	0.2	52 850
FR	88.9	0.1	39 136
DE	87.4	2.8	66 714
GR	80.9	2.5	48 843
HU	-	-	-
IE	80.8	7.7	29 182
IT	93.0	0.2	53 531
LV	75.9	1.8	34 003
LT	92.3	0.2	49 623
LU	86.0	0.3	17 677
MT	93.5	0.6	28 443
NL	86.0	0.8	12 509
PL	85.1	1.5	31 151
PT	77.2	0.4	32 916
RO	79.1	5.5	32 587
SK	83.0	0.5	42 948
SI	89.9	0.0	25 684
ES	72.3	0.8	57 621
SE	71.7	6.8	52 411
GB	81.1	6.6	64 640
EA	85.7	1.2	574 912
EU	83.8	2.5	995 918

Note: For country names and abbreviations see Table A1.

Table A7a: Share (in percent) and number of households that answered both the question on perceived inflation and the question on the likelihood of spending a large amount of money on home improvement or renovation as distributed according to answer categories

	ANSWER CATEGORIES ON LIKELIHOOD OF DOING RENOVATION		
COUNTRY	VERY LIKELY (%)	FAIRLY LIKELY (%)	NOT LIKELY (%)
AT	18.1	16.2	30.4
BE	19.1	10.9	7.3
BG	2.9	9.4	14.6
HR	2.7	9.9	22.3
CY	6.1	7.5	8.3
CZ	16.6	16.2	23.2
DK	13.6	9.3	10.6
EE	17.2	22.9	12.2
FI	16.7	7.5	4.6
FR	16.0	8.9	7.3
DE	4.1	16.4	32.3
GR	2.8	5.7	16.3
HU	-	-	-
IE	7.1	10.3	18.2
IT	3.2	6.3	6.8
LV	6.2	21.8	23.0
LT	2.6	10.9	17.9
LU	22.4	13.4	6.1
MT	5.7	5.3	8.6
NL	23.8	4.8	6.2
PL	6.2	17.8	26.9
PT	2.1	5.4	23.4
RO	5.7	17.5	16.3
SK	4.2	15.2	24.1
SI	13.3	14.9	12.7
ES	1.7	5.8	24.1
SE	21.8	19.7	14.1
GB	9.4	13.1	22.2
EA	9.2	9.7	17.0
EU	9.1	11.7	17.5

Note: For country names and abbreviations see Table A1.

Table A7b: Share (in percent) and number of households that answered both the question on perceived inflation and the question on the likelihood of spending a large amount of money on home improvement or renovation as distributed according to answer categories

	ANSWER CATEGORIES ON LIKELIHOOD OF DOING RENOVATION		
COUNTRY	NOT AT ALL LIKELY (%)	DON'T KNOW (%)	NO OF RESP.
AT	35.1	0.2	57 094
BE	62.3	0.5	44 718
BG	62.4	10.7	31 932
HR	61.8	3.3	29 393
CY	71.4	6.7	25 822
CZ	43.0	1.0	30 444
DK	66.4	0.2	34 606
EE	47.2	0.4	3 535
FI	70.4	0.8	52 641
FR	67.4	0.3	37 589
DE	42.4	4.8	67 602
GR	72.6	2.6	53 066
HU	-	-	-
IE	55.7	8.7	30 804
IT	83.3	0.4	59 167
LV	43.6	5.4	36 102
LT	67.2	1.5	50 468
LU	57.6	0.5	18 023
MT	74.7	5.7	35 742
NL	64.6	0.6	11 941
PL	45.0	4.1	33 741
PT	68.2	0.9	33 810
RO	55.0	5.6	35 158
SK	55.3	1.2	43 800
SI	59.0	0.1	25 837
ES	67.1	1.4	64 425
SE	40.3	4.1	51 944
GB	48.4	6.9	63 740
EA	62.2	2.0	600 288
EU	58.3	3.4	1 020 193

Note: For country names and abbreviations see Table A1.

Table A8a: Share (in percent) and number of households that answered both the question on expected inflation and the question on the likelihood of spending a large amount of money on home improvement or renovation as distributed according to answer categories

	ANSWER CATEGORIES ON LIKELIHOOD OF DOING RENOVATION		
COUNTRY	VERY LIKELY (%)	FAIRLY LIKELY (%)	NOT LIKELY (%)
AT	18.1	16.2	30.3
BE	18.6	10.8	7.1
BG	2.9	9.7	15.0
HR	2.8	10.1	22.6
CY	6.2	7.8	8.2
CZ	16.8	16.4	23.4
DK	13.8	9.3	10.6
EE	13.6	19.0	10.8
FI	16.6	7.5	4.6
FR	15.5	8.9	7.4
DE	4.2	16.5	32.4
GR	2.9	5.9	17.5
HU	-	-	-
IE	7.1	10.3	18.6
IT	3.1	6.2	6.9
LV	6.4	22.6	23.1
LT	2.6	11.0	18.0
LU	22.7	13.5	6.0
MT	6.1	5.5	9.3
NL	23.7	4.8	6.2
PL	6.3	18.0	27.1
PT	2.2	5.4	23.0
RO	5.8	17.8	16.5
SK	4.2	15.2	24.1
SI	13.4	15.0	12.8
ES	1.7	5.9	24.7
SE	21.8	19.6	14.1
GB	9.5	13.1	22.1
EA	9.4	9.8	17.2
EU	9.3	12.0	17.6

Note: For country names and abbreviations see Table A1.

Table A8b: Share (in percent) and number of households that answered both the question on expected inflation and the question on the likelihood of spending a large amount of money on home improvement or renovation as distributed according to answer categories

	ANSWER CATEGORIES ON LIKELIHOOD OF DOING RENOVATION		
COUNTRY	NOT AT ALL LIKELY (%)	DON'T KNOW (%)	NO OF RESP.
AT	35.1	0.2	56 601
BE	63.0	0.5	44 676
BG	62.1	10.3	28 920
HR	61.3	3.2	27 612
CY	71.7	6.1	22 802
CZ	42.4	1.0	29 481
DK	66.1	0.2	34 129
EE	52.9	3.7	18 904
FI	70.5	0.7	52 850
FR	68.0	0.2	39 136
DE	42.2	4.7	66 714
GR	71.0	2.7	48 843
HU	-	-	-
IE	55.8	8.3	29 182
IT	83.5	0.4	53 531
LV	42.9	5.0	34 003
LT	67.0	1.4	49 623
LU	57.4	0.4	17 677
MT	75.6	3.5	28 443
NL	64.6	0.7	12 509
PL	44.8	3.7	31 151
PT	68.6	0.8	32 916
RO	54.7	5.3	32 587
SK	55.3	1.2	42 948
SI	58.6	0.1	25 684
ES	66.3	1.3	57 621
SE	40.5	3.9	52 411
GB	48.5	6.8	64 640
EA	61.8	1.8	574 915
EU	57.9	3.2	995 918

Note: For country names and abbreviations see Table A1.

Table A9: Estimated coefficients for the likelihood variable 'CAR' and test of difference by country. Perceived and expected inflation rates are functions of one of the three likelihood variables (car, house and renovation), income, work regime, education, and age. The coefficients for the socioeconomic variables are presented in Table A12 to Table A15 in the Appendix.

	PERCEIVED INFLATION			EXPECTED INFLATION		
	CAR			CAR		
COUNTRY	LIKELY	NOT LIKELY	DIFF	LIKELY	NOT LIKELY	DIFF
AT	0.06	0.19	-0.13*	-0.28	-0.19	-0.09*
BE	-0.83	-0.61	-0.23**	-0.71*	-0.56	-0.15**
BG	3.70*	5.65*	-1.95***	3.58*	6.24*	-2.66***
HR	-0.05	1.79*	-1.84***	0.24	1.75*	-1.52***
CY	-0.89*	0.24	-1.13***	-2.98*	-2.88*	-0.10
CZ	0.13	0.59	-0.46***	0.46	1.20*	-0.74***
DK	1.27*	1.25*	0.02	0.85*	0.79*	0.06
EE	0.47	1.14	-0.67**	-1.13*	-0.75*	-0.37**
FI	0.40*	0.42*	-0.02	0.43*	0.43*	0.01
FR	-1.00	-0.73	-0.27***	0.09	0.22	-0.12***
DE	0.37*	0.36*	0.01	0.48*	0.32*	0.16***
GR	1.92*	4.07*	-2.16***	-0.54	2.24*	-2.79***
HU	-	-	-	-	-	-
IE	6.02*	6.67*	-0.65***	2.63*	3.00*	-0.37***
IT	0.83	1.55	-0.72***	0.93*	1.13*	-0.20**
LV	0.73*	0.80*	-0.07	0.36	1.10*	-0.74***
LT	-0.47	0.53	-0.99***	-0.15	1.02*	-1.17***
LU	-0.92	-0.84	-0.09	-1.29*	-1.17*	-0.12*
MT	-2.05*	-1.05*	-1.00***	-2.45*	-0.98*	-1.47***
NL	-0.61	-0.34	-0.27*	-0.04	-0.01	-0.03
PL	0.22	1.70*	-1.47***	0.31	1.50*	-1.19***
PT	-1.13*	-0.66	-0.47***	-0.87*	-0.61	-0.25*
RO	-0.51	1.81*	-2.32***	-0.49	1.24*	-1.73***
SK	-0.84*	0.04	-0.88***	-0.20	0.57	-0.77***
SI	0.45	1.01	-0.55***	-1.04	-0.79	-0.25*
ES	-0.36	0.72	-1.08***	-0.34	0.52	-0.87***
SE	-1.08*	-1.10*	0.03	-0.66*	-0.73*	0.07***
GB	0.30*	0.90*	-0.60***	-0.11	0.18*	-0.29***
EA	1.26*	1.72*	-0.46***	0.15*	0.58*	-0.43***
EU	1.04*	1.60*	-0.56***	0.30*	0.81*	-0.51***

Note: For the answer categories 'likely' and 'not likely' an asterisk represents significance at the 5% level. For the differences between the two, asterisks represent a significance level of: *** = 1%, ** = 5% and * = 10%.

For country names and abbreviations see Table A1.

Table A10: Estimated coefficients for the likelihood variable 'HOUSE' and test of difference by country. Perceived and expected inflation rates are functions of one of the three likelihood variables (car, house and renovation), income, work regime, education, and age. The coefficients for the socioeconomic variables are presented in Table A12 to Table A15 in the Appendix.

	PERCEIVED INFLATION			EXPECTED INFLATION		
	HOUSE			HOUSE		
COUNTRY	LIKELY	NOT LIKELY	DIFF	LIKELY	NOT LIKELY	DIFF
AT	-0.01	0.32	-0.34***	-0.83	-0.58	-0.25***
BE	-0.55	-0.19	-0.36***	-0.07	0.11	-0.18**
BG	4.67*	6.06*	-1.39***	5.45*	6.71*	-1.26**
HR	0.32	1.90*	-1.59***	-0.05	1.70*	-1.76***
CY	-0.58	0.37	-0.95***	-3.93*	-3.71*	-0.22
CZ	0.61	0.92	-0.31	1.84*	2.41*	-0.56***
DK	1.03*	1.27*	-0.24***	0.75*	0.86*	-0.11*
EE	-0.61	0.48	-1.09***	-1.07*	-0.77*	-0.30
FI	0.57*	0.63*	-0.06	0.27	0.31	-0.04
FR	-0.53	-0.04	-0.49***	-0.97	-0.85	-0.13**
DE	0.59*	0.43*	0.16	0.58*	0.35*	0.24***
GR	3.08*	4.89*	-1.81***	0.75	2.24*	-1.49***
HU	-	-	-	-	-	-
IE	6.24*	6.90*	-0.67***	2.67*	3.07*	-0.40***
IT	1.52	1.50	0.02	0.57	0.68	-0.11
LV	1.02*	1.40*	-0.38*	1.10*	1.71*	-0.61**
LT	0.06	2.05*	-1.99***	-0.54	1.72	-2.26***
LU	0.86	0.62	0.24**	0.01	0.13	-0.13
MT	-1.86*	-0.67*	-1.18***	-2.54*	-1.26*	-1.29***
NL	-0.31	0.11	-0.42*	0.02	0.19	-0.18*
PL	0.76	1.76*	-1.00***	0.37	1.21*	-0.85***
PT	-0.93*	-0.66	-0.27	0.19	0.49	-0.30**
RO	-0.43	1.51*	-1.94***	-0.37	1.28*	-1.65***
SK	0.62	0.91*	-0.30*	1.34*	1.79*	-0.46**
SI	5.17	5.89	-0.72***	0.69	1.28	-0.58***
ES	-0.14	0.44	-0.58**	0.92*	1.16*	-0.24
SE	-1.07*	-1.17*	0.09***	-0.70*	-0.78*	0.08**
GB	0.14	0.85*	-0.71***	-0.33*	0.18*	-0.51***
EA	2.00*	2.50*	-0.50***	0.42*	0.79*	-0.37***
EU	1.12*	1.75*	-0.63***	0.27*	0.76*	-0.49***

Note: For the answer categories 'likely' and 'not likely' an asterisk represents significance at the 5% level. For the differences between the two, asterisks represent a significance level of: *** = 1%, ** = 5% and * = 10%.

For country names and abbreviations see Table A1.

Table A11: Estimated coefficients for the likelihood variable 'RENOVATION' and test of difference by country. Perceived and expected inflation rates are functions of one of the three likelihood variables (car, house and renovation), income, work regime, education, and age. The coefficients for the socioeconomic variables are presented in Table A12 to Table A15 in the Appendix.

	PERCEIVED INFLATION			EXPECTED INFLATION		
	RENOVATION			RENOVATION		
COUNTRY	LIKELY	NOT LIKELY	DIFF	LIKELY	NOT LIKELY	DIFF
AT	0.37	0.55	-0.18***	0.40	0.43	-0.04
BE	-0.26	-0.13	-0.13***	-0.47	-0.46	0.00
BG	3.18*	4.57*	-1.39***	3.05*	5.39*	-2.34***
HR	-0.84*	0.96*	-1.80***	0.20	2.11*	-1.91***
CY	-0.71*	0.30	-1.01***	-4.94*	-4.05*	-0.89***
CZ	0.07	0.43	-0.36***	0.77	1.25*	-0.48***
DK	1.17*	1.28*	-0.10***	0.80*	0.83*	-0.03
EE	0.05	0.52	-0.47***	-0.98*	-0.64*	-0.34***
FI	0.39*	0.39*	0.00	0.05	0.03	0.02
FR	0.41	0.70	-0.29***	0.22	0.37	-0.15***
DE	0.62*	0.30*	0.33***	0.55*	0.24*	0.31***
GR	2.64*	4.71*	-2.07***	-0.07	2.54*	-2.61***
HU						
IE	6.07*	6.35*	-0.28***	2.43*	2.68*	-0.26***
IT	0.84	2.20*	-1.37***	0.66	0.58	0.09
LV	0.89*	0.93*	-0.04	0.55	1.26*	-0.71***
LT	0.61	1.69*	-1.08***	0.18	1.59*	-1.41***
LU	1.03*	0.89	0.14***	-0.19	-0.22	0.04
MT	-2.44*	-1.66*	-0.78***	-3.66*	-2.71*	-0.96***
NL	1.66*	2.00*	-0.33***	-0.44	-0.38	-0.05
PL	0.69*	1.01*	-0.32***	0.84*	0.99*	-0.15
PT	-1.06*	-0.57	-0.49***	-1.08*	-0.54	-0.53***
RO	-0.20	1.54*	-1.74***	-0.68*	1.21*	-1.89***
SK	0.29	0.64*	-0.35***	-0.08	0.22	-0.30***
SI	0.08	1.01	-0.93***	0.60	1.24	-0.64***
ES	0.17	0.92*	-0.74***	-0.25	0.33	-0.58***
SE	-0.87*	-0.97*	0.10***	-0.54*	-0.62*	0.08***
GB	0.27*	0.99*	-0.71***	-0.21*	0.26*	-0.46***
EA	1.01*	1.43*	-0.42***	-0.10	0.19*	-0.29***
EU	0.92*	1.53*	-0.60***	0.24*	0.72*	-0.48***

Note: For the answer categories 'likely' and 'not likely' an asterisk represents significance at the 5% level. For the differences between the two, asterisks represent a significance level of: *** = 1%, ** = 5% and * = 10%.

For country names and abbreviations see Table A1.

Table A12: Estimated regression coefficients for the socioeconomic variable 'INCOME'. Extends the results from the regressions presented in Table A9, Table A10 and Table A11.

	PERCEIVED INFLATION				EXPECTED INFLATION			
		INCOME QUARTILE				INCOME QUARTILE		
COUNTRY	C	II	III	IV	C	II	III	IV
AT	14.36***	-0.14***	-0.19***	-0.68***	10.31***	0.06	0.06	-0.13***
BE	17.96***	0.30***	-0.63***	-1.49***	18.33***	0.35***	0.11	-0.51***
BG	24.16***	0.92***	0.61***	-0.21	17.84***	1.62***	0.74***	-0.53***
HR	4.20***	0.40***	0.43***	0.28	7.39***	0.50***	0.59***	0.84***
CY	21.36***	-0.15	-0.68***	-2.15***	20.19***	0.30***	0.34***	-0.64***
CZ	20.04***	0.48***	0.00	-0.24***	6.03***	0.55***	-0.08	-0.61***
DK	-7.42***	0.24***	0.04	-0.66***	-5.41***	0.32***	0.26***	-0.25***
EE	1.78	-0.11	0.45	0.15	2.97***	-0.11	-0.16	-0.21
FI	8.90***	0.17***	0.12***	-0.13***	9.63***	0.13***	0.11***	-0.04
FR	15.26***	-0.05	-0.19***	-0.78***	0.54	0.09***	0.06	-0.07
DE	2.30***	-0.35***	-0.58***	-0.80***	3.36***	0.03	-0.21***	-0.37***
GR	13.97***	-0.12	1.11***	0.80***	8.63***	-0.13	0.65***	-0.83***
HU	-	-	-	-	-	-	-	-
IE	7.02***	0.46***	0.01	-1.49***	1.84***	0.30***	0.34***	-0.54***
IT	2.43***	0.52***	-0.92***	-0.85***	-2.81***	0.45***	0.37***	0.32***
LV	9.94***	-0.23	-1.06***	-2.10***	1.75***	-0.02	-1.15***	-2.36***
LT	8.47***	-0.32***	-0.66***	-1.71***	7.89***	-0.05	-0.47***	-1.65***
LU	0.84	0.15	0.16	-0.39***	-0.51	-0.02	0.01	-0.12
MT	12.41***	0.86***	2.31***	2.51***	20.31***	1.29***	2.28***	1.37***
NL	10.83***	-0.27	-0.42***	-1.25***	9.16***	0.00	-0.01	-0.26***
PL	9.81***	-0.18	-0.40***	-0.61***	6.52***	-0.23	-0.51***	-0.77***
PT	11.08***	-0.13	-0.16***	-0.04	7.26***	-0.13	-0.19***	0.05
RO	32.47***	0.49***	-0.38***	-1.40***	23.02***	0.33	0.00	-0.91***
SK	-5.13***	-0.54***	-0.95***	-1.37***	-6.40***	-0.56***	-1.03***	-1.50***
SI	-14.64***	0.23	-0.31***	-1.15***	-10.11***	0.31***	-0.04	-0.61***
ES	-20.73***	1.22***	0.04	-0.56***	-7.33***	0.29***	-0.41***	-0.61***
SE	-6.40***	0.02	-0.04	-0.14***	-4.79***	0.08***	0.03	-0.14***
GB	-19.47***	-0.09	-0.48***	-1.25***	-12.06***	0.11	-0.04	-0.74***
EA	3.97***	0.18***	-0.18***	-0.75***	3.60***	0.11***	-0.01	-0.28***
EU	5.21***	0.19***	-0.10***	-0.70***	3.71***	0.20***	0.07***	-0.36***

Note: Asterisks represent a significance level of: *** = 1%, ** = 5% and * = 10%
For country names and abbreviations see Table A1.

Table A13: Estimated regression coefficients for the socioeconomic variable 'WORK REGIME'. Extends the results from the regressions presented in Table A9, Table A10 and Table A11.

	PERCEIVED INFLATION			EXPECTED INFLATION		
	WORK REGIME			WORK REGIME		
COUNTRY	UNEMPLOYED	PART TIME	FULL TIME	UNEMPLOYED	PART TIME	FULL TIME
AT	0.58***	0.25***	0.08	0.23***	0.17***	0.03
BE	0.22	0.04	0.05	-0.06	0.07	0.16***
BG	4.50***	5.63***	4.85***	4.39***	5.42***	5.12***
HR	1.52***	-0.48	0.97***	1.57***	0.04	0.95***
CY	2.28***	1.74***	1.65***	-0.08	0.17	0.94***
CZ	0.50***	1.07***	0.35***	0.72***	1.16***	0.78***
DK	1.42***	0.42***	0.39***	1.12***	0.38***	0.27***
EE	1.71***	-0.28	0.17	0.84***	-0.23	0.13
FI	0.01	0.02	0.11***	0.04	-0.02	0.04
FR	0.36***	0.19	0.19***	0.13	0.05	0.16***
DE	0.72***	-0.13	-0.09	0.45***	0.03	0.00
GR	1.45***	0.11	-0.09	1.16***	0.75***	-0.24
HU	-	-	-	-	-	-
IE	0.37***	0.78***	0.57***	0.49***	0.49***	0.50***
IT	1.07***	1.75***	0.91***	0.51***	0.34***	0.06
LV	0.53***	0.17	0.62***	0.42***	-0.57***	0.50***
LT	1.30***	-0.16	1.13***	1.66***	0.34	1.31***
LU	-1.05***	-0.79***	-0.80***	-0.38***	-0.05	0.03
MT	1.20***	0.53***	-0.28***	0.96***	0.55***	-1.06***
NL	0.60	-0.16	0.08	0.24	-0.20	-0.15
PL	-0.90***	-0.94***	-0.48***	-1.46***	-1.06***	-0.61***
PT	1.13***	0.77***	0.42***	0.90***	0.18	0.26
RO	-0.27	-0.13	-0.24	-1.37***	-0.94	-1.33***
SK	1.15***	0.62***	0.28***	0.97***	0.59***	0.25***
SI	0.32	0.92***	0.67***	0.82***	1.19***	0.77***
ES	0.74***	-0.28	-0.37***	0.36***	-0.28	-0.11
SE	-0.08	0.01	-0.07***	0.07	0.06	0.02
GB	0.49***	-0.23***	-0.37***	0.31***	-0.16***	-0.31***
EA	0.79***	0.26***	0.16***	0.45***	0.01	0.03
EU	0.71***	-0.06	0.00	0.61***	-0.11***	0.01

Note: Asterisks represent a significance level of: *** = 1%, ** = 5% and * = 10%
For country names and abbreviations see Table A1.

Table A14: Estimated regression coefficients for the socioeconomic variables 'EDUCATION' and 'SEX'. Extends the results from the regressions presented in Table A9, Table A10 and Table A11.

	PERCEIVED INFLATION			EXPECTED INFLATION		
	EDUCATION		SEX	EDUCATION		SEX
COUNTRY	SECONDARY	FURTHER	FEMALE	SECONDARY	FURTHER	FEMALE
AT	-0.78***	-1.63***	1.49***	-0.20***	-0.49***	0.62***
BE	-0.13	-0.93***	1.60***	0.14***	0.13***	-0.01
BG	-0.74***	-2.12***	0.16	-0.97***	-2.29***	0.30***
HR	-0.63***	-3.16***	0.74***	-0.39***	-2.43***	0.47***
CY	0.21	-0.21	0.84***	-0.09	-0.94***	0.95***
CZ	-0.10	-0.53***	1.04***	0.25***	-0.74***	1.35***
DK	-0.97***	-1.20***	0.36***	-0.61***	-0.60***	0.14***
EE	-0.18	-0.95***	0.53***	0.57***	0.11	0.54***
FI	0.04	-0.21***	0.19***	0.02	-0.07***	0.02
FR	0.26***	-0.04	0.26***	0.38***	0.44***	-0.15***
DE	-0.18***	-0.71***	0.27***	0.05	-0.13***	0.07***
GR	-1.05***	-1.49***	1.59***	-1.00***	-1.24***	1.18***
HU	-	-	-	-	-	-
IE	-0.45***	-1.65***	1.39***	-0.43***	-0.90***	0.73***
IT	-2.55***	-4.53***	2.77***	-0.07	0.03	-0.11***
LV	0.11	-0.23	0.93***	0.29***	-0.33	0.78***
LT	1.67***	0.94***	0.20***	1.03***	0.40***	0.34***
LU	0.24***	-0.69***	1.15***	0.31***	-0.07	0.43***
MT	-1.45***	-2.56***	0.15***	-2.15***	-3.57***	0.29***
NL	-0.50***	-1.60***	1.51***	0.19***	0.13	0.00
PL	-0.26***	-1.48***	0.80***	-0.39***	-1.65***	0.53***
PT	-0.43***	-1.07***	0.71***	-0.19***	-0.53***	0.40***
RO	-0.61***	-2.11***	0.77***	0.07	-1.07***	0.96***
SK	-0.28***	-0.89***	0.29***	-0.14	-0.55***	0.35***
SI	0.35***	-0.46***	1.49***	0.29***	-0.24	1.05***
ES	-1.09***	-2.35***	1.45***	-0.26***	-0.69***	0.37***
SE	0.00	-0.24***	0.10***	-0.02	-0.24***	0.07***
GB	0.17	-0.38***	1.81***	-0.12	-0.62***	1.04***
EA	-0.53***	-1.23***	1.00***	-0.06***	-0.32***	0.37***
EU	-0.40***	-0.93***	0.92***	-0.06***	-0.46***	0.45***

Note: Asterisks represent a significance level of: *** = 1%, ** = 5% and * = 10%
For country names and abbreviations see Table A1.

Table A15: Estimated regression coefficients for the socioeconomic variable 'AGE'. Extends the results from the regressions presented in Table A9, Table A10 and Table A11.

	PERCEIVED INFLATION			EXPECTED INFLATION		
	AGE			AGE		
COUNTRY	30-49	50-64	65+	30-49	50-64	65+
AT	-0.17***	-0.15***	-0.75***	0.25***	0.35***	-0.16***
BE	0.30***	0.49***	-0.07	-0.16	0.18	-0.38***
BG	1.55***	2.27***	2.46***	1.13***	1.77***	2.08***
HR	1.97***	2.26***	1.77***	1.67***	2.02***	1.59***
CY	1.89***	1.51***	1.91***	0.79***	0.28	0.25
CZ	0.35***	0.58***	0.87***	0.69***	1.02***	0.88***
DK	0.06	0.13***	0.13	-0.20***	0.06	-0.15***
EE	0.62***	-0.06	-0.17	0.54***	0.57***	-0.76***
FI	0.19***	0.24***	0.33***	0.26***	0.28***	0.12***
FR	0.43***	0.28***	-0.44***	0.25***	0.35***	-0.30***
DE	0.16***	0.02	-0.15	0.14***	0.19***	0.26***
GR	0.13	-0.34***	-0.30***	0.53***	0.34***	-0.05
HU	-	-	-	-	-	-
IE	-0.34***	-0.85***	-1.40***	-0.05	-0.17***	-0.66***
IT	-2.04***	-3.65***	-4.95***	-0.16	-0.23***	-0.44***
LV	1.08***	1.30***	1.16***	1.19***	1.41***	1.32***
LT	0.63***	1.88***	3.40***	0.78***	2.00***	2.88***
LU	0.34***	0.26***	-0.23***	0.07	0.36***	0.01
MT	0.01	-0.10	-0.71***	0.04	-0.50***	-1.37***
NL	0.64***	0.34	0.53	0.26***	0.37***	-0.04
PL	1.02***	1.52***	0.91***	0.94***	1.22***	0.41***
PT	0.01	-0.60***	-0.73***	0.06	-0.48***	-0.52***
RO	1.99***	2.96***	2.77***	1.56***	2.61***	2.29***
SK	0.63***	1.21***	1.99***	0.64***	1.27***	1.88***
SI	0.55***	0.17	-0.73***	0.01	-0.15	-1.07***
ES	-0.28***	-1.54***	-2.22***	-0.06	-0.69***	-1.26***
SE	0.15***	0.36***	0.58***	0.11***	0.43***	0.41***
GB	-0.03	-0.05	-0.51***	-0.18***	-0.13***	-0.44***
EA	0.26***	-0.09***	-0.58***	0.36***	0.34***	-0.02
EU	0.61***	0.46***	0.04	0.56***	0.66***	0.34***

Note: Asterisks represent a significance level of: *** = 1%, ** = 5% and * = 10%
For country names and abbreviations see Table A1.

4 The price and risk effects of option introductions on the Nordic markets

4.1 Introduction

4.1.1 Background

With the opening of the Chicago Board Options Exchange (CBOE) in 1973 a new era of derivative trading started. CBOE revolutionised the option trading by creating standardised, listed stock options. In the same year Black and Scholes (1973) published their work on option pricing. They assumed that options are redundant assets and could thereby derive a pricing rule for derivative securities. This was done by applying a no-arbitrage argument and by constructing a dynamic hedge portfolio. Since then academics have questioned the assumption of redundancy. Researchers recognise that financial markets are not complete. Therefore, introducing derivative securities could increase the opportunity set of investors, which in turn could make markets more efficient, lead to welfare effects, and make the derivatives market interact with the underlying securities market (see, e.g., Ross 1976; Hakansson 1982; and Detemple and Selden 1991).

This study empirically investigates the effects of option introduction on the prices and risk of the underlying securities. The data used come from the stock markets in Denmark, Finland, Norway, and Sweden as well as from the option market in Sweden. The study is motivated fourfold:

(i) One reason is to check the results and implications of theories regarding option introduction presented in the academic literature.

(ii) So far most studies concerning the impact of option listing on the underlying stock has been based on data from the United States. To

confirm the results from these studies evidence from other data sets are needed.

(iii) Recent studies based on US data have found time-varying price and risk effects. These, from most other findings divergent, results will be compared with those based on data from the Nordic markets.

(iv) Policy questions arise, because there is a fear that derivative trading adds to the instability of the underlying assets market. Not rarely such trading gets the blame for increased uncertainty. The proposed solutions to the presumed problem include introducing frictions into the market, such as turnover taxes on short-term positions, to reduce the speed of transactions. Although no explicit conclusions can be drawn, it is worthwhile checking if the allegation of adding instability has any empirical support.

There are several arguments suggesting that there exist effects on the underlying stock returns related to the listing of options. The structure, magnitude or even the directions of these effects are debatable, but they are potentially of great interest, not only to academics, but also to practitioners and market regulators. However, a better understanding of the effects involved can only be determined empirically.

The disposition of this chapter is as follows. The final part of the introduction provides some theoretical arguments leading to the hypothesis tested in the paper, and also gives a review of the empirical literature. Section two discusses the methodology. The following section describes the data. Section four presents the results, and in the final section the conclusions are summarised. Appendix A and B put forward derivations of parts of the methodology. In Appendix C all the shares of the companies used in this study are listed, together with their announcement and listing dates.

4.1.2 Theory and tested hypothesis

The aim of this study is to contribute to a better understanding of the effects of option introduction by examining evidence from the Nordic stock markets. There are several variables to be examined and there are several mechanisms by which the variables may be affected. More exhaustive reviews, both regarding the theoretical and empirical literature, can be found in the surveys of Damodaran and Subrahmanyam (1992) and Gjerde and Sættem (1994).[14]

[14] The last survey of the two is written in Norwegian.

Price effects

Derivative securities are efficient and flexible instruments for controlling financial risks. These instruments enable different risk positions and opinions about risks to be expressed through trading, and thereby contribute to the reallocation of the risks among different market participants. Among other things, the access to a developed option market allows investors to unload their risks without having to change their positions in the underlying stock. This implies reduced transaction costs and makes it possible to manage better the investors' risk exposure in the underlying market, which should be beneficial both privately and to the society.

In a complete market all assets are perfect substitutes, and contingent cash flow claims can be duplicated by combining already existing assets (see Black and Scholes 1973). In a complete market, options are therefore redundant assets. An important economic theorem states that a complete market is always pareto-efficient, while an incomplete market may be pareto-inefficient (see Cox and Rubinstein 1985, p 435). Practical circumstances prevent the construction of such a complete market. Among other things, simple contracts may be difficult to write and carry out, e.g. contracts on future labour income. Further, transaction costs and regulations could make it difficult to construct new derivative securities for all possible outcomes. Options could therefore in practice contribute to making the capital markets more complete. To the degree that investors are better off by their increased opportunity set when options are introduced, it can be claimed that the additional trading possibilities reduce the investors' cost of capital and increase the price of the underlying stock.

A negative external effect of trading options could be that this trading diverts capital from the equity market to the derivative market. This could lead to a higher liquidity premium, and therefore a higher required return and more expensive equity. Cox and Rubinstein (1985) recognise a problem connected with this line of argument, which is in conflict with a fundamental economic principle. Call and put options are contracts between individuals or financial intermediaries, and are not issued by non-financial firms. At a national level, aggregated real asset value corresponds to the sum of aggregated equity, convertible instruments, and debt. Like any form of debt between individuals or financial intermediaries, options are not included in this balance. A holder of an option contract has claims corresponding to the other party's obligations. A buyer of a call option is a potential buyer of the stock, but has not yet bought it. Similarly, a seller of a call option is a potential seller of the underlying stock. Therefore, it is not correct to say that buying an option represents a reduction in the total net demand of the stock. A more nuanced argument would be that

the availability of an option market leads to a new equilibrium, whereby the total investment level could be either higher or lower.

Few papers have theoretically dealt with the implications from non-redundant option markets for the underlying price. Detemple and Selden (1987) provides one line of argument. They construct a general equilibrium model of an economy consisting of a risky asset and an option, where the asset market is assumed to be incomplete. The economy is populated by two types of investors, with homogenous utility functions, but with different beliefs about the risk connected with stock prices. They assume that there are two classes of investors who disagree on the probability of a fall of the stock price, i.e. there is a 'high-risk' group and a 'low-risk' group of investors. The option increases the number of attainable returns. In this incomplete market the derivative and the underlying assets will interact, i.e. their valuation becomes a simultaneous pricing problem.

Individuals with high-risk assessments have preferences for payoffs for high values of the stock, and therefore want to buy and hold call options to hedge the downside potential. For the high-risk investors the option serves as a substitute: they buy the call option while selling some of their shares in the endowed stock. The low-risk investors do the opposite; they demand the stock and supply the call option, and thus treat the derivative security as a complement to the stock. The net effect is that the demand for the stock increases. The stock is regarded to be more valuable when options are introduced, and the price increases. Further, the return volatility of the stock decreases.

The price effect occurs initially at the time of the introduction of the call contract, but could be anticipated. This could give rise to an arbitrage opportunity. By buying the stock before the actual introduction of the option one could secure an additional profit. Therefore, it is likely that a price effect should occur at the announcement date.

The model has nothing to say about any welfare effects that could arise when an option is introduced. But through an enhanced opportunity set, and given the investors' different risk assessments, consumption can be more easily smoothed, which should be beneficial to the economy as a whole. The positive price effect can be expected to be permanent, as the required yield on investments can be reduced.

Conrad (1989) suggests that another explanation for a price effect is the market makers' higher demand for stocks for hedging purposes when new stock options are introduced. In the case market makers anticipate writing calls, they

might demand the underlying stock for inventory and hedging purposes. This should lead to a temporary price increase, likely to occur at the introduction day or a few days before the actual listing of new derivatives. Vice versa, if the market makers anticipate writing puts, they may short the stock for the same reasons. This should lead to a temporary price pressure in the stock at the introduction date, or a few days before. Other examples can also be constructed, giving rise to both price increases and price decreases.

In an efficient market, price changes can be expected to occur at the announcement date and not at the date of the option introduction. If regulatory or institutional constraints exist, it is possible to have a price effect on the introduction date. In Haddad and Voorheis (1991) it is argued that the most interesting time to analyse is the introduction date. Most option-traders want to issue covered options, but this strategy is not possible to implement before the options are actually traded.

Risk effects

Concerning the risk effects of option introductions, Grossman (1988) states that trading in standardised derivative contracts reveals information about the demand for financial insurance to the counterpart, who supplies this insurance. He argues that the price variance in the underlying security will decline when trade in standardised contracts is introduced, as opposed to the case when this demand for financial insurance is generated through dynamic trading strategies, i.e. re-balancing the portfolio between risky assets and risk-free lending/borrowing.

A purpose of his study is to show how market frictions and incomplete information regarding the fraction of portfolio managers that implement a dynamic hedging strategy can leave liquidity providers unprepared to meet the increased supply induced by the portfolio hedgers. This causes the stock price to be more volatile than it would have been if put options had been traded.

It is crucial that liquidity providers know the fraction of portfolio managers who decide to use dynamic hedging strategies to be able to make a correct capital allocation decision. In the absence of perfect information about the fraction of portfolio insurers, the liquidity providers will choose to provide an amount of capital that is optimal for some average level of volatility. This leads to situations in which the allocated capital is less than demanded in times of high volatility, and is in excess in times of low volatility. Therefore, the stabilising role of the liquidity providers will be undermined by imperfect

information about the fraction of investors implementing dynamic hedging strategies.

In this situation a tradable put option may have an important role to fill. Suppose there exists a put option, and that the portfolio insurers implement their strategies via the derivative contract. The price of the put will then reveal the fraction of investors committed to dynamic hedging strategies. In the presence of real traded derivative contracts, the liquidity providers are informed about the fraction of portfolio insurers and thus can allocate their capital in an optimal and market-stabilising way.

Therefore, it is rational to assume that the introduction of options is likely to reduce the total risk.

Focusing on two aspects of speculative behaviour, risk-sharing and information transmission, Stein (1987) analyses the risk effect connected with the introduction of derivatives. In his model the opening of a derivative market produces new investment choices, and enables more and new agents to participate in the economy, which improves the risk-sharing. The new agents are also differently informed, which can alter the informational content of prices. His model illustrates that the opening of a derivative market can be destabilising.

Two mechanisms will determine the effects on price volatility and welfare. First, the opening of a derivative market will introduce more agents into the economy, and make it possible to transfer the risk of holding inventories to the new pool of investors. When inventories are more easily carried forward from one period to another, prices become more stable, which leads to a smoother allocation of consumption. It is assumed that consumers have concave utility functions. Thence it follows that consumption smoothing over time is welfare-improving.

The second mechanism affecting the prices has to do with the inference, which can be drawn from the observed asset price. If the derivative market is in place, and the new traders have imperfect information, their speculative trading can reduce the informational content of the asset's price. This muddling of the traders' information has two effects. It raises their conditional variance of the future price. Since traders are risk averse, they will be more reluctant to hold an inventory, which prevents consumption smoothing. This gives a destabilising effect. Traders also make mistakes in their storage decisions, because they have to statistically predict the future price. Again, this is destabilising. These two effects are of course reduced by the risk-sharing

benefit provided by new traders. Still, the net effect may be destabilising and welfare-reducing.

Thus, the introduction of derivative instruments may also have a destabilising effect on the underlying market, which tends to increase volatility and thereby the total risk.

Option trading could also open up opportunities for a manipulation of prices, and this could lead to destabilisation. Examples of such a manipulation are strategies called 'pooling' and 'capping'. When implementing a 'pooling' strategy, a holder of a call option uses the fact that options are highly leveraged instruments, i.e. the value of an option changes relatively more than that of the underlying stock. Thus, by trying to raise the stock price, it is possible to gain an additional return on a long position in a call option written on that particular stock. This strategy can be implemented at any time of an option's life as soon as it is introduced.

'Capping' is a strategy where an issuer of a call option tries to push down the price of the underlying stock during the time of maturity. Selling off stocks at this particular period of time can lead to a lower price, which reduces the value of the options, and in the extreme case makes them worthless. The opposite tactics, called 'pegging', can be used to avoid such a reduction of the underlying stock price. Both 'capping' and 'pegging' can contribute to non-normal fluctuations in the stock price around the maturity of the option.

Another manipulation opportunity is connected with the front running of block holders, which involves taking advantage of information about a coming block trade by earning a profit through buying or selling options on the underlying stock. This type of action is closer to insider trading, and is easier to regulate and supervise than the type of manipulations mentioned above.

According to Damodaran and Subrahmanyam (1992), arguments about the destabilising effect of option trading can be found in the popular press. In general, these arguments are not presented within the framework of a model, but are based on two factors, according to Damodaran and Subrahmanyam. First, in a market with frictions in the trading process, the actions of uninformed speculators can generate price bubbles, i.e. prices are determined by other factors than fundamental values. Second, actions like programmed trading by some market participants, such as index arbitrageurs and suppliers of portfolio insurance, tend to increase the speed of response to changes in market situations, which can accelerate market declines or increases, and thus add to volatility.

4.1.3 Review of empirical literature

The empirical findings concerning the effects of option introductions on the underlying stock prices can be divided into at least four areas, namely (i) the price level, (ii) the volatility, (iii) the information and price adjustment process, and (iv) the microstructure effects (i.e. spreads and volume). This study deals mainly with the first two issues. The following review of the empirical literature should by no means be seen as a complete review.[15] It is summarised in Table 1 below. Further, since this study does not deal with issues concerning variations in the underlying stock around the time of maturity of the options, such literature will be omitted in this review.

Price effects

Starting with the price effect, empirical findings employing data from US markets suggest that option introduction causes a permanent price increase in the underlying stock, beginning a few days before the introduction. Using a sample of 300 option introductions between 1973 and 1986, Detemple and Jorion (1990) report positive abnormal returns averaging 0.6% on the listing day, and 2.9% in the two weeks around the listing date. They also show that the effects are stronger in the earlier part of their sampling period than in the later years.

The price effect also seems to be more associated with the time of introduction, rather than the time of announcement. Conrad (1989) distinguishes between the announcement of a new listing and the actual listing. The sample used consists of 96 option introductions made between 1974 and 1980 at 30 different dates. She finds a positive abnormal return of 2.5% during the period from 3 days before to 1 day after the option listing. She could find no price effect around the announcement date.[16]

The absence of an announcement effect is somewhat puzzling since investors should progressively realise that the prices of newly optioned stocks usually increase. Hence, an announcement effect should appear.

In a more recent study the price effect is reconsidered. Sorescu (2000) shows that the effect of option introductions on the underlying stocks is best described

[15] There are some master theses from Stockholm School of Economics (using Swedish data) that are dealing with the issues discussed in this study. These papers will not be taken into consideration in the review that follows.

[16] Other students of the return effect of option introductions include Branch and Finnerty (1981), Rao and Ma (1987), and Haddad and Voorheis (1991).

by a two-regime switching means model. He finds a positive return effect of 2.37 percent over an 11-day window around the listing date of the options introduced from 1973 to 1980. In the period after 1980 he finds a negative effect of -1.52 percent. The sample consists of 1924 listings made on 877 separate dates.

An attempt was made to explain the causes of the switch in the price effect by observable characteristics of the optioned firms, instead of by the underlying economics of option introduction. Two such variables were age and size, which showed to be negatively related to the time of introduction. In the sample of the optioned stocks after 1980, the firms are relatively smaller and younger. For this group of stocks, the costs of establishing short positions may be high before the option listing, such that investors with negative information who do not own the stock are unable to borrow it. These short sale restrictions are effectively removed when options are listed. Thus, negative information can be incorporated in prices and lead to a negative price effect. Other characteristics, also used, were the type of contracts listed, and the trading place of the options and their underlying stock.

The results show that the switch around 1980, from positive to negative abnormal returns, is not related to the type or trading place of the option contract, nor to the age, size or trading place of the underlying stock. The cross-sectional characteristics in the underlying firms merely serve as proxies for the regime switch.

Recognising that option listing is an endogenous decision made by exchanges, Mayhew and Mihov (1999) investigate the factors affecting the exchanges' listing decisions. They find that firm size, volume, and volatility are positively related to the probability of listing. Using these results, they construct matched samples of stocks that were eligible, but not selected, for option listing, and re-examine some of the option listing effects using a control sample methodology, in order to correct for an eventual selection bias problem.

They use a sample consisting of 1953 stocks with options introduced between 1973 and 1996. The results show that there is a positive price effect prior to 1980 and a negative one after 1980. But in the years after 1980 the control samples also show negative excess returns. Thus, the negative return effect in the later period is less pronounced than that reported by Sorescu, and in some cases it even disappears.

So far, most studies concerning the impact of option listing on the underlying stock have been based on data from the United States. There is, however, some

evidence regarding the effects of option introductions based on data sets outside the US.

Watt, Yadav, and Draper (1992) used 39 option listings (over 34 independent dates) made in the UK over the period 1978 to 1989, and report a temporary price increase of 1.3% immediately prior to the listing. Stucki and Wasserfallen (1994) investigate the effect on stocks traded in Switzerland. Their sample consists of 11 option introductions made at one single date in 1988. They find that the introduction of traded options leads to a permanent and significant increase in the prices of 2%. Gjerde and Sættem (1995) have a sample of 7 option introductions, listed at 4 individual dates in Norway. They report a temporary price increase, giving a positive excess return of 1% on the introduction day. Finally, findings from the Netherlands, as reported by Kabir (1998), indicate a decline in the stock prices. The magnitude of the decline was –2.3% over the 20 days before the listing and –0.46% on the day after the listing. The sample used consists of 53 option listings made at 27 individual dates during the period 1978 to 1993.

There is one study based on stocks traded in Sweden by Alkebäck and Hagelin (1998). Mainly they study the impact of warrant introduction on the underlying stocks, and for comparison they also study the effects of option introductions made in Sweden. Alkebäck and Hagelin report that the return is unchanged at the introduction of the options. The differences between this study and theirs are that in this study the sample of option introductions include all Nordic markets, and that the question of an announcement effect is addressed. Further, the risk analysis is extended to include both the effects on the systematic risk and those on the unsystematic risk.

All the studies mentioned above, using data from European markets, have the weakness of not considering what happens at the announcement date. Another shortfall is that the studies using data from Norway and Switzerland contain very few independent observations.

Risk effects

To date, most studies on the aspect of the impact of option markets are concerned with the effects on volatility. The consensus among studies using samples up to the mid-eighties is strong regarding the effects, and the findings show that volatility is reduced as a consequence of the introduction of options.

Applying variance measures of excess returns, Conrad (1989) finds that the average variance, measured over the 200 days preceding the option introduction compared to the value measured over the following 200 days,

shows a decline from 2.29% to 1.79%. At the individual firm level, 86 of the 96 firms introduced during the period between 1974 and 1980 showed a reduction in variance. Skinner (1989) proves a decline in variance of 17%-25% after the listing of options depending on the time interval used. The sample consists of raw returns from 304 stocks with options introduced during the period 1973-1986. When the actual returns are adjusted day by day with due allowance for the overall market returns, the decline is in the order of 10%. In a sample consisting of 300 stocks with options introduced during the years between 1973 and 1986, DeTemple and Jorion (1990) find that the total risk declines on an average by 7%. Damodoran and Lim (1991) document a significant decline in the return variance of 21%. Their sample consists of 200 stocks with options introduced between 1973 and 1983. Nabar and Park (1994) develop a market model approach to investigate the effects of options on the underlying assets, as opposed to the earlier studies directed to tests of variance ratios. In a sample of 390 optioned stocks introduced at 153 different dates, they find that the variance corrected for market risk is reduced on the average by 4-8%.[17] Mayhew and Mihov (1999) find diverging results depending on the time period studied. Between 1973 and 1980 they find decreasing volatility compared to the control samples of stocks, but in the period following 1980 they find mixed results. They even report a significant increase in volatility during the period 1991 to 1996. They interpret this as if exchanges listed options in response to the stocks' permanent characteristics, but as these listing candidates became fewer over time, the exchanges gradually began listing the options in response to changes in market conditions. Thus, this reflects a change in the listing criteria, the exchanges become forward-looking, and list options in anticipation of high volatility.

Another risk examined is the non-diversifiable risk, measured by the beta of the underlying stock. An early study by Trennepohl and Dukes (1979) uses a sample of weekly returns from 32 optioned stocks, which were listed between 1970 and 1976. The average weekly-return beta in their sample declines from 1.22 before the listing to 0.87 after the listing. Klemkosky and Maness (1980) also come to a similar conclusion comparing monthly-return betas before and after the listing of options, but their results are statistically weaker. The sample consists of monthly returns on 39 optioned stocks during the period 1972-1978. More recent studies with an improved methodology and larger data sets have not been able to find any significant change in betas after the option listing.

[17] Other scholars have come to the same conclusion regarding reduced risk. Among these are Ma and Rao (1988), and Bansal, Pruit, and Wei (1989).

Examples of such studies are Whiteside, Dukes and Dunne (1983), Skinner (1989), and Damodoran and Lim (1991).

The results reported by researchers using data sets from non-US markets are as follows. Regarding the total risk the results are mixed. Watt, Yadav, and Draper (1992) report that the total risk and the unsystematic risk decreased in the UK. Stucki and Wasserfallen (1994) investigate the effect on stocks traded in Switzerland. They find a reduction in the volatility of the stock returns of 31%. Sahlström (1998) using a sample of 13 option introductions made in Finland, finds that the total volatility is reduced by 31%. The study based on stocks traded in Sweden by Alkebäck and Hagelin (1998) report that the variance declines by 14%. With a sample of 37 option introductions made over the period 1979 to 1987 in Canada, Chamberlain, Cheung, and Kwan (1993) fail to find any significant effects on risk, volume, and bid-ask spreads. Gjerde and Sættem (1995) find no evidence of a change in the total risk of the stocks in Norway. Finally, findings from the Netherlands, as reported by Kabir (1998), indicate no significant change in volatility. The evidence on systematic risk measured by beta is more conclusive. No effect is found in the studies from Canada, Norway, the Netherlands, Switzerland, or the UK. The only exception is the study based on Swedish option introductions, which reports a decline in beta.

In summary, the empirical evidence on different risk measures indicates that stock return variance declines after option listing. This is true for both total risk and unsystematic risk. Only a weak or, more recently, no statistically significant change is found in the systematic risk measured by the beta of the underlying stock.

Information and price adjustment process effects

Several studies have documented the speed at which new information is incorporated in equity prices, both those with and those without options. At least three issues in this connection are examined in the academic literature. The first one is concerned with the effect option listing can have on the quantity and quality of the information produced. The second deals with the speed at which the prices of optioned stocks respond to new information relative to non-optioned stocks. A third issue is to what extent option prices lead or lag the prices of the underlying stocks.

Damodoran and Lim (1991) study the issue concerning the quantity and quality of the information produced. They look at the number of analysts following a stock and the frequency of Wall Street Journal articles about the company

before and after the option listing. They conduct a test of whether the information structure is affected by option listing, and find a significant increase in the number of analysts concerned with stocks with options as well as a higher frequency of Wall Street Journal articles.

The speed of price adjustment to new information has been studied by Jennings and Stark (1986), among others. In a sample of 180 stocks having options introduced during 1981 and 1982, they find that the price of the optioned stocks adjusts more quickly to earning reports than to the non-optioned stocks of a matched sample. Skinner (1990), also studying the effect of earnings announcements on optioned stocks relative to non-optioned stocks, reports smaller abnormal returns of unexpected news after the listing of options. Further, he concludes that the overall reaction to earnings reports is smaller after the listing of options. The sample in Skinner's study consists of 214 stocks having options introduced during the period 1973 to 1986, at 82 listing dates. Using the variance in different return intervals, Damodoran and Lim (1991) estimate price adjustment coefficients. Using a sample of 200 firms covering the period of 1973-1983 they find that prices adjust quicker to new information after the listing of options.

The last issue, dealing with which market responds to new information most quickly, the option market or the stock market, has been addressed by Manaster and Rendleman (1982), among others. They use a sample of 172 stocks with options listed between 1973 and 1976. They find that the option prices lead the stock prices by as much as 24 hours. In addition, they calculate the differences between implied and actual stock prices. On the basis of these differences they construct portfolios, which make excess returns. This result, however, has been challenged in other studies. For example, Stephan and Whaley (1990), using intraday price changes in 364 stocks with options traded during 1986, find that option prices lag stock prices by 15-20 minutes. They also document a modest feedback from the option markets.

In summary, there is evidence that option listings enhance the information set and increase the speed with which new information is incorporated in prices. However, the answer to the question whether it is the option market or the stock market that leads the information revelation remains open.

Table 1 Some effects of option listing

Presented below is a summary of studies mentioned in the text above regarding the effects of option listing on returns, total risk, systematic risk, bid-ask spreads, and volume. In these studies excess returns are defined as the difference between the raw return and the market-adjusted return with market model parameters estimated from a prior time period. The total risk is usually measured by the return variance, sometimes adjusted to market variance. The systematic risk is measured by the beta of a stock. The bid-ask spreads are estimated using the Roll covariance method. The volume is measured by raw volume or market-adjusted volume. Weekly returns are used in earlier studies and daily in the later ones.

STUDY	COUNTRY	SAMPLE SIZE	SAMPLE PERIOD	EXCESS RETURN	TOTAL RISK	SYSTEMATIC RISK	BID-ASK SPREADS	VOLUME
Trennephol & Dukes (1979)	USA	32	1970-76			Decline		
Klemkosky & Maness (1980)	USA	39	1972-80			Decline		
Whiteside, Dukes & Dunne (1983)	USA	71	1973-81			None		
Conrad (1989)	USA	96	1974-80	+2.5%	-22%	None		
Skinner (1989)	USA	304	1973-86		-10%	None		Increase
DeTemple & Jorion (1990)	USA	300	1973-86	+2.9%				
Damodoran & Lim (1991)	USA	200	1973-86		-21%			No change
Watt, Yadav, & Draper (1992)	GBR	39	1978-89	+1.3%	-12%	None		
Chamberlain, Cheung, & Kwan (1993)	CAN	37	1979-87		None	None	None	No change
Nabar & Park (1994)	USA	390	1973-85		-4% to -8%			
Stucki & Wasserfallen (1994)	CHE	11	1988	+2.1%	-31%	None		
Gjerde & Sættem (1995)	NOR	7	1990-94	+1.0%	None	None	Decline	Increase
Alebäck & Hagelin (1998)	SWE	32	1985-94	None	-14%	Decline	Decline	Increase
Kabir (1998)	NLD	53	1978-93	-2.3%	None	None		
Sahlstöm (1998)	FIN	13	1992-95		-31%		Decline	
Mayhew & Mihov (1999)	USA	1953	1973-96	< 0	Increase			Increase
Sorescu (2000)	USA	1924	1973-95	-2.4				

Market microstructure effects

Theory suggests that options trading may have market microstructure effects. In the empirical literature it is hypothesised that bid-ask spreads and trading volume are affected. Damodoran and Lim (1991) estimate the serial correlation measure for the bid-ask spread proposed by Roll (1984), using a sample of 200 firms with options introduced during the period 1973-1986. They reached the conclusion that the bid-ask spreads declined after the listing of options. The decline is partially attributed to an increase in competition among market makers on the option market, and is partially due to an increased institutional trading activity in the stock.[18]

Studies dealing with the effects of option listing on trading volume have come to diverged conclusions. Skinner (1989) reports how the stock market trading volume changes around the listing time of options. The sample consists of 297 firms with options introduced between 1973 and 1986. The result indicates that the median trading volume in the stock increases after the listing by 17%.[19] Likewise, Damodoran and Lim (1991) report an increase in the raw trading volume of the same magnitude, but when controlling for general market changes the effect is insignificant.[20]

In summary, it seems like the bid-ask spread decreases after the listing of options, and there is no or little effect on the market-adjusted trading volume of the underlying stock.

4.1.4 Hypothesis

Based on the arguments above, four explicit hypotheses regarding a return effect are tested in this study. Since the return effect is a priori indeterminate, both regarding the time and the direction of a shift, the tests are designed to allow for either an increase or a decrease in the returns. Further, an effect is allowed to take place at both the announcement date and the introduction date. If a shift in the return-generating process is found, it is also tested if it is

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[18] Others have also studied the effects on the bid-ask spread. Among them are Neal (1987) and Fedenia and Grammatikos (1992), and they draw similar conclusions as Damodoran and Lim (1991).

[19] Jennings and Stark (1986) also find a positive volume effect of option introduction.

[20] Whiteside, Dukes and Dunne (1983) and Bansal, Pruit, and Wei (1989) draw similar conclusions as Damodoran and Lim (1991), i.e. there is no change in volume when options are introduced.

reversed at a later date following either the announcement or the introduction. The hypotheses are:

H1 Option introductions do not lead to a change in the price of the underlying assets at the announcement date.

H2 In the case of a price effect at the announcement, the effect is not reversed.

H3 Option introductions do not lead to a change in the price of the underlying asset at the introduction date.

H4 In the case of a price effect at the introduction, the effect is not reversed.

As regards a risk effect, theory is not conclusive about in what direction the risk might shift. Thus, also in this case, the tests must allow for either an increase or a decrease in risk. Moreover, the theoretical analyses referred to above are not comprehensive enough to disentangle which risks are affected and how, i.e. the effect on the systematic and/or idiosyncratic risks. According to the theories it is clear that the total risk is affected, but it is hard to say what happens in a setting with more than one asset and how this affects the relation with other assets. This raises the questions of which risks are affected, and how. Three explicit hypotheses are tested in this study concerning a risk effect caused by the introduction of options:

H5 Option introductions do not change the total risk of the investments in the underlying assets, measured by the variance in returns.

H6 Option introductions do not change the idiosyncratic risk.

H7 Option introductions do not change the systematic risk, measured by beta.

4.2 Methodology

4.2.1 Return effect

To investigate the price effect of an option introduction, an event study is undertaken based on introduction of options on the Nordic exchanges. The event is defined in two distinct ways. The first way is to use the announcement date of an option introduction as it appears in a newsletter from Options Mäklarna (OM) and Oslo Stock exchange (OSE), or in the newspaper Dagens Industri. The second way is to use the first day of trade of the standardised

contract, as reported by the respective exchange. Throughout the study, continuously compounded returns are calculated in a standard fashion:

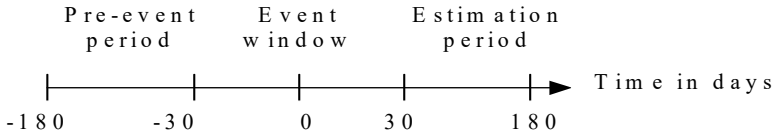
$$r_t = ln(p_t - d_t) - \ln p_{t-1} \quad (1)$$

In the equation above p_t denotes the price and d_t denotes the dividend at date t.

The securities on the Nordic exchanges are infrequently traded in comparison with stocks traded on the New York Stock Exchange (NYSE). Thus, there will be days with no closing prices and therefore missing values in the return series. In such cases, a return is calculated for the period of missing prices. For example, if closing prices are missing for two days, a three-day return is calculated using the third day's price.

In sample one and two, the event window is defined to be 61 days, that is 30 days prior to the event day and 30 days after the event day. Calculating abnormal returns for a security, the normal return over the event window is subtracted from the actual ex-post return. A modified market model implementing Fowler and Rorke (1983) betas, which adjusts for non-synchronous trading, is used to model the normal returns. The parameters in the market model are estimated on data in a window of 150 days after the event window (see Figure 1). The pre-event period is used for alternative choices of estimation periods.[21]

Figure 1 Time line for the event study



When many options in the sample are introduced on the same calendar date, cross-sectional correlation in excess returns could give biased results. Therefore, equally weighted portfolios are formed out of those stocks, which have identical option introductions and announcement dates. These portfolios are treated as individual securities. An inference is drawn by calculating z-

[21] Other specifications of the estimation period are also tried, e.g. 150 days before and 150 days after the event window, and just 150 days before the event window. The choice does not affect the results. But, as will be seen later, there is a risk of a selection bias in the data set, which could have an influence on the estimation of the parameters of the normal return models.

scores from the standardised excess returns of the securities for each day in the event window. The methodology is more exhaustively presented in Appendix A.

4.2.2 Risk effect

The second part of this analysis deals with the effect of an option introduction on the total risk, the idiosyncratic risk and the systematic risk of the underlying security. Using a similar event-study approach as in the analysis of the return effect, the total risk effect is first investigated.

Total risk

Monthly variances are estimated from daily returns for 21 consecutive days. Since there are periods of days with no closing prices, there will be days without returns. Therefore, some variances will be estimated by using fewer returns than 21. This infrequent trading of securities causes the returns to be autocorrelated, particular at a one day lag (see Scholes and Williams (1973)). Because of this autocorrelation, variances are estimated as:

$$\sigma_{it}^2 = \frac{1}{N_{it}}\sum_{k=1}^{N_{it}}\left(r_{itk} - \bar{r}_{it}^{v}\right)^2 + \frac{1}{N_{it}}\sum_{k=1}^{N_{it}-1}\left(r_{itk} - \bar{r}_{it}^{c}\right)\left(r_{it,k-1} - \bar{r}_{it}^{c}\right) \qquad (2)^{22}$$

σ_{it}^2 Stock or market variance

N_{it} Number of trading days in a month

r_{itk} Daily return in day k within month t

$\bar{r}_{it}^{v}$ Mean return in month t excluding missing returns

$\bar{r}_{it}^{c}$ Mean return of the returns used when calculating the one-period lagged cross product[23]

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[22] It should be noted that the covariance term in equation (2) does not enter by a factor two as it usually does. This is due to a Newey-West correction in order to make the variance-covariance matrix positive semidefinite in small samples (see Hamilton 1994, p 281). If the covariance matrix is not positive semidefinite, it is not asserted that all variances are non-negative.

[23] The two mean returns $\bar{r}_{it}^{v}$ and $\bar{r}_{it}^{c}$ are essentially the same, but since cross products are calculated, resulting in more missing values, they could differ. The reason for $\bar{r}_{it}^{c}$ to differ from $\bar{r}_{it}^{v}$ could be that the time series of 21 consecutive days, used to estimate a monthly variance, include missing values. When the time series is lagged one day, and multiplied with the original (not lagged) time series to calculate cross products, the days following a missing value will become cross products of missing values. The number of cross products,

A market model for monthly stock variance is used to describe the normal variance, i.e. the individual stock variance is expected to fluctuate around its mean and the variance is adjusted for shifts in the overall market variance. Three different market models for variances are considered:

$$\sigma_{it}^2 = a_i + b_i\sigma_{mt}^2 + e_{it}$$
$$\sigma_{it} = a_i + b_i\sigma_{mt} + e_{it} \quad (3)$$
$$\ln \sigma_{it} = a_i + b_i \ln \sigma_{mt} + e_{it}$$

Nabar and Park (1994) specify these market models for volatility ad hoc. They use these models to answer similar questions as asked in this study, and they show that the methodology is statistically more powerful than comparing variance ratios adjusted for market volatility, as in Skinner (1989). The advantage of this specification of normal variances is that it adjusts to a potential market shift in volatility. It also makes it possible to follow the development of the excess volatility over time. Empirical results found by Schwert and Seguin (1990) support such a statistical model. The modelled normal variances are compared with realised monthly return variances, and the differences are considered to be the abnormal variances, as follows:

$$\hat{e}_i^* = \sigma_i^* - \hat{a}_i l - \hat{b}_i\sigma_m^* \quad (4)$$

In equation (4) the star superscript indicates that the vectors of standard deviations come from the event window, while $\hat{a}_i$ and $\hat{b}_i$ are estimated with data from the estimation period (see Figure 2). The abnormal variance can then be aggregated across stocks, and thereafter tested if it is significantly different from zero. Test statistics and hypotheses are developed in the same way as for the test concerning significant abnormal returns. As in the return study, a cross-sectional correlation in excess variances could bias the results. Therefore, equally weighted portfolios are formed out of the stocks having identical option introduction dates. Portfolios are formed before variances are calculated, and they are treated as individual securities.

The timing of the events of the risk effect is presented in Figure 2. The first sub-period is the 44 months' estimation period, while the second period is the

therefore, become fewer than the number of days in the original time series. For example, if there is one day missing out of the original 21 days, the resulting number of cross products is 18. One is lost due to the lagging of the series, and two more are lost due to the missing day. The mean return $\overline{r}_{it}^c$ is calculated by only using those returns which result in a cross product that does not result in additional missing values, i.e. in the example the 18 returns resulting in an existing cross product are used.

event window with 10 months prior to the listing and 10 months after the listing. The first day in month 1 is the listing day of any stock option. The pre-listing period in the event window is used to verify the predictability of the model. The post-listing period in the event window is used to test for excess volatility in returns.

Figure 2 Time line for the event study

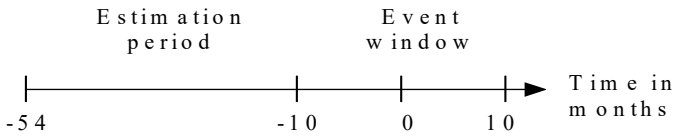


Table 2 shows summary statistics from the three specified volatility models in equation (3). It can be seen from the table that all estimated parameters are significant with one exception: the slope coefficient in the variance model. All models produce similar results. The ordinary least squares (OLS) estimation of the models in (3) shows that the residuals exhibit a significant serial correlation for many stocks. Therefore, the OLS estimates of the model coefficients will be biased. Instead, the methodology developed by Nabar and Park (1994) will be used, i.e. implementing generalised least squares (GLS) estimates of the parameters in the models, and adjusting for first order autocorrelation. The methodology is explicitly presented in Appendix B.

Table 2 Summary statistics for volatility market model regressions

The table shows summary statistics from the regression models in equation (3). Separate regressions are conducted using variances from portfolio returns. Each portfolio consists of securities having the same introduction date. In each column the mean of each coefficient is displayed. Columns 2-5 show the parameter estimates with their respective standard deviations. A first order autocorrelation from OLS residuals is presented in column 6, the coefficient of determination in column 7, and in the last column the average skewness in the residuals.

MODELS	$\overline{\alpha}$	$\overline{\sigma}_a$	$\overline{b}$	$\overline{\sigma}_b$	$\overline{\rho}$	$\overline{R}^2$	SKEWNESS
σ^2	0.079	0.030	1.60	0.854	0.202	0.20	2.10
σ	0.212	0.048	0.61	0.288	0.268	0.18	1.14
$\ln\sigma$	-0.799	0.271	0.26	0.132	0.288	0.14	0.04

To facilitate the interpretation, and due to a higher R^2, the model using market standard deviation as explanatory variable is chosen. The results are essentially the same regardless of the choice of model specification.[24]

Idiosyncratic risk

Variance ratios are used in testing for a change in the idiosyncratic risk. The same methodology is also used for the test of changes in the total risk in such a way that a comparison can be made between the two risks.

When calculating the variance ratios for the idiosyncratic risk, the variances of residuals from a market model for each stock are computed for a ten-month period on either side of the option introduction date. To get the total risk effect, the variances of the stock returns are calculated. The variances of the corresponding market returns are also calculated on either side of the stock's listing date. This is done for each stock separately, using the same ten-month period. Dividing the post-listing period variance by the pre-listing period variance forms variance ratios (VR). Presented in equation (5) and (6) are the variance ratios for the idiosyncratic and total risks. The superscripts I and T indicate which risk is considered, the idiosyncratic or total risk.

$$VR_i^I = \frac{\sigma^2_{\varepsilon_i, post-listing}}{\sigma^2_{\varepsilon_i, pre-listing}} \tag{5}$$

$$VR_i^T = \frac{\sigma^2_{i, post-listing}}{\sigma^2_{i, pre-listing}} \tag{6}$$

To control for coexisting shifts in the market risk, the stock variances in each period is divided by the corresponding market variance. The quotient between the stock variances and the market variance is the market-adjusted or standardised variances. Dividing the standardised variances after the listing by the standardised variances before the listing forms the standardised variance ratio (SVR). Presented in equation (7) and (8) are the variance ratios of the idiosyncratic and total risks.

$$SVR_i^I = \frac{\sigma^2_{\varepsilon_i, post-listing} / \sigma^2_{M, post-listing}}{\sigma^2_{\varepsilon_i, pre-listing} / \sigma^2_{M, pre-listing}} \tag{7}$$

[24] The parameters in Table 2 appear to differ considerably depending on the choice of model, and could potentially lead to a question of robustness in the results. This difference is due to the transformation of the monthly time series, and has no effect on the results whatsoever. All models were tested, and the conclusions drawn are the same regardless of the model used.

$$SVR_i^T = \frac{\sigma^2_{i_i,post-listing}/\sigma^2_{M,post-listing}}{\sigma^2_{i_i,pre-listing}/\sigma^2_{M,pre-listing}} \quad (8)$$

A VR or a SVR greater than one indicates an increase in the overall risk in each stock. A ratio less than one indicates a reduction in volatility. An F-test is performed on each security's variance ratio to test for significant deviations from one. The median variance ratio is also tested for a significant deviation from one by a Wilcoxson-signed rank test.

Systematic risk

To test if option introduction has any impact on the systematic risk of the underlying securities, a market model regression is estimated over 360 days. Half of the data set occurs before the option listing, and the other half after the option listing. To adjust for the bias in the coefficient estimates arising from thinly traded securities, the approach of Fowler and Rorke (1983) is followed. A dummy variable is included in the model that takes the value one in the periods following the option listing and zero otherwise. More specifically, the following model is estimated:

$$R_i = \alpha_i + \beta_i^{--}\beta_m^{--} + \beta_i^{-}R_m^{-} + \beta_i^{0}R_m^{0} + \beta_i^{+}R_m^{+} + \beta_i^{++}R_m^{++} + \\ +\gamma_i D_i\left(\beta_i^{--}\beta_m^{--} + \beta_i^{-}R_m^{-} + \beta_i^{0}R_m^{0} + \beta_i^{+}R_m^{+} + \beta_i^{++}R_m^{++}\right) + \varepsilon_i \quad (9)$$

In the regression model R_i and R_m represent vectors of stock returns and market returns, respectively. The superscripts ++, +, 0, -, and -- indicate that each time series is shifted to lead or lag two days, one day, or no day. A γ_i-coefficient significantly different from zero indicates that the option listing may have affected the beta values. The null hypothesis tested is $\sum_i \gamma_i = 0$. D_i represents the dummy vector.

4.3 Data

This study is based on all stocks on which options were listed in the four Nordic countries Denmark, Finland, Norway, and Sweden between the years 1985 and 1998. During this period there were a total of 90 listings at 62 individual dates. The option introduction dates are the dates reported by the respective exchange in each country. The announcement dates were collected from newsletters from Options Mäklarna (OM) and Oslo Stock Exchange (OSE). For the first two years the sample announcement dates were gathered from Dagens Industri, a major Swedish business newspaper.

Three samples are collected and used in this study. Sample one and two consist of daily stock return data aligned at the announcement date and at the introduction date respectively. Sample three consists of 64 months of daily stock returns aligned at the introduction date. It is used to calculate 64 monthly variances. Sample one is used to test hypothesis (i) and (ii). Sample two is used to test hypothesis (iii), (iv), (vi), and (vii). Sample three is used to test hypothesis (v).

All observations in all three samples included in the study must meet the following criteria. When options are introduced on several types of stocks of a company, only the first introduction is considered. This means that if the options on Volvo B-shares were introduced before those on Volvo A-shares, only the Volvo B option introduction date will be considered in the study.[25] After this has been taken into account, 85 stocks remain. In sample one and two, the individual shares must have been publicly traded 180 days prior to and 180 days after the considered date. The 361-day interval is chosen to match the estimation period. This reason for the rejection of data excludes 27 stocks. The selection criterion results in a remaining sample of 58 stock option introductions, and the number of different introduction dates is 37. Announcement dates could only be received on introductions made in Sweden and partly in Norway. This shortfall reduces the number of announcements to 39, at 27 individual dates.[26]

Table 3 shows the number of option introductions that have occurred in the Nordic countries, and the number of stocks that had to be excluded because of the selection criteria. Out of the 58 listings in the final sample the majority are Swedish. In sample three, which is used in the study of the risk effect, the individual shares must have been publicly traded 54 months prior to and

[25] The sample includes companies, which have as many as four types of stocks. Two of these, A-shares and B-shares, refer to voting rights. Both types can also be classified as restricted or unrestricted, referring to whether domestic or foreign ownership is allowed. This last classification does no longer exist.

[26] For comparison, Conrad (1989), the most widely cited paper in the area, used 96 stock options in her study. After the forming of portfolios there were 30 portfolios at the introduction date and 15 at the announcement date.

Table 3 Number of listings and announcements, and sample falloff

The first four rows show the number of option introductions in each of the Nordic countries between 1985 and 1998. Row five and six are the sum of all introductions on all exchanges, and the total number of dates at which these introductions occurred. The following rows, seven through nine, give the number of introductions that had to be excluded from the study. The three reasons for excluding the events are 'Already existing', 'Lack of data', and 'No announcement'. The first one is concerned with companies that already have options introduced on other types of shares. The second takes into account that the price series in the underlying stocks are too short. The third tells the number of introductions where no announcement date could be attained. The rows ten through thirteen show the final number of listing dates and announcement dates that are included in the study. The last four rows show the final number of listing dates and announcement dates distributed over the four Nordic countries.

	YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Σ
COUNTRY	Denmark						4			2	1					7
	Finland									7	6					13
	Norway						5	1		1	1		1	6	4	19
	Sweden	6	4	3	2	5	2	1	2	6	3	5	9	3		51
	Total listings	6	4	3	2	5	11	2	2	16	11	5	10	9	4	90
	Total dates	1	2	2	2	4	4	2	2	9	10	5	10	6	3	62
	Already existing			1			1				1		1	1		5
	Lack of data			1		1	1	1		5	5	2	7	2	2	27
	No announcements						9	1		10	8		1	2		31
SAMPLE	Listings	6	4	1	2	4	9	1	2	11	5	3	2	6	2	58
	Listing dates	1	2	1	2	3	3	1	2	8	4	3	2	4	1	37
	Announcements	6	4	1	2	4	1	0	2	5	2	3	2	5	2	39
	Announcem. dates	2	2	1	2	3	1	0	1	5	1	3	2	3	3	27

	DENMARK	FINLAND	NORWAY	SWEDEN	
Listings	6	5	14	33	58
Listing dates	2	3	8	25	37
Announcements	0	0	6	33	39
Announcem. dates	0	0	3	24	27

10 months after the introduction date.[27] Due to the longer return horizon required when calculating variances, fewer stock option introductions can be considered. The selection criterion results in 48 stock option introductions at 31 individual dates. Only introduction dates are considered when the risk effect is studied. Since monthly variances are used, and introduction dates and announcement dates are close together in time, the results are not affected.

The price and dividend data are drawn from SIX Trust and Datastream.[28] The market index is Datastream's Scandinavia-DS Market index (SDSM), which is a value-weighted total return index.[29]

Table 4 Descriptive statistics of return series for the total sample period, and before and after option introduction

The sample of 361 trading days is divided into three time periods, signed Total, Before, and After, The last two consist of the first and last 150 trading days, excluding the middle 61 trading days. Separate regressions of the type $R_{it} = \alpha_{it} + \beta_{it} Rm_{it} + \varepsilon_{it}$ are run for each stock and period individually. The values presented in the table are the averages of the estimated parameters and standard deviations. Columns 2 to 5 contain the sample average of the parameter values from the regressions with the corresponding average standard deviation. Columns 6 and 7 contain the standard deviation for the return series. The last column contains market-adjusted standard deviations.

PERIOD	$\overline{\alpha}$	$\overline{\sigma}_{\alpha}$	$\overline{\beta}$[a]	$\overline{\sigma}_{\beta}$	$\overline{\sigma}_{i}$	$\overline{\sigma}_{m}$	$\overline{\sigma}_{i}/\overline{\sigma}_{m}$
Total	0.0006	0.0010	0.4927	0.1105	0.3392	0.1560	2.12
Before	0.0010	0.0017	0.3786	0.1829	0.3571	0.1527	2.23
After	0.0002	0.0016	0.4472	0.1632	0.3346	0.1647	1.99
σ_{AL}/σ_{BL}[b]					0.94	1.08	

Note: a) In the 'Total' period 49 out of the 58 estimated betas are significantly different from zero at a five percent significance level. In the 'Before' period 33 betas are significant, and in the 'After' period 37 betas are significant.

b) Quotient between the standard deviation after listing and the standard deviation before listing.

Table 4 shows descriptive statistics of the return series concerning the sample of stocks. Each stock in the sample is studied during a total interval of 361 consecutive trading days around the listing, 150 days 'Before', 61 days around and 150 'After' the listing. Two observations can be made from Table 4. The average beta increases after the option introduction, and rises from 0.3786 to

[27] Outside of this time interval too many shares would have to be excluded. Some options have been introduced recently, which means that not enough time has elapsed between the introduction and today's date, to generate relevant return data. Also, some stocks were not publicly traded prior to the considered introduction and announcement dates. The introduction of the stock and the option occurred close together in time, which prohibits a satisfactory estimation of model parameters.

[28] Trust is a financial database, which is administered by Scandinavian Information Exchange (SIX).

[29] Included in the index are 220 stocks, out of which the Danish, Finnish, and Norwegian markets contribute with 50 stocks each, and the Swedish with the residual 70.

0.4472. This shift in beta is not significant at any conventional significance level. After the option introduction the standard deviation is reduced on average by 6% in the underlying stocks, while the total market volatility increases by 8% on an average over the corresponding period. This means that the optioned stocks show a decreasing volatility during a period whereas the rest of the market shows an increase in volatility. This could potentially be an indication of a selection bias in the sample. It is possible that the options are introduced in the beginning of a period of rising volatility. The exchanges have a selection procedure to be able to see which securities have the necessary prerequisites for listing, where market conditions and circumstances in general are taken into account. Variables affecting the decision are likely to be, among others, volume, size, and liquidity. A consequence could be to that the sample of optioned stocks differs from that of non-optioned stocks.

4.4 Results

4.4.1 Return effect

The main results of the study are presented in Table 5 and Table 6. Note that in Table 5 the announcement day data are used, which only include stock returns from Norway and Sweden. In Table 6 returns from all Nordic markets are included.

Announcement effect

As a point of departure, abnormal returns around the announcement date are examined. It can be seen from column three in Table 5[30], showing the t-statistic for the excess return at each day, that there is essentially no evidence of excess returns on the announcement day. There is a small increase on day 0 of 0.15 percent, with a t-statistic of 0.37. However, on the day after the announcement there is a substantial excess return of one percent, strongly significant with a t-statistic of 2.67. Since the market participants in some cases do not have the possibility to immediately absorb and analyse the information on option introductions, or if the announcements reach them late in the afternoon, they may react either on day 0 or day 1. To check if traders do respond to the

[30] In Table 5 results from 21 days in the event window are presented. During the excluded 40 days there are 5 days showing significant excess returns, out of which four occur in the pre-listing period.

information on either the day of the announcement or the day after that, the cumulative effect over day 0 and 1 is tested. Over the two days the return effect is positive and amounts to 1.17 percent, which is significant with a t-statistic of 2.14. It is also worth noting that 67 percent of the securities on day 1 show positive excess returns. Thus, hypothesis (i) is rejected, as the outcome shows that there is a positive price effect of an option introduction in connection with the announcement.

Table 5 Average and cumulative return residuals, and test statistics, around option introduction announcement

The table shows 21 out of 61 daily excess returns and cumulative excess returns in the event window, defined to be 30 days before and after the announcement day of an option introduction. To calculate excess returns, a one-factor market model is used to describe normal returns, which are then subtracted from realised returns. The estimated parameters in the market model are adjusted for asynchronous trading using the Fowler-Rorke [1983] methodology to calculate betas. Thirty-nine stocks from Norway and Sweden are used and are grouped into 27 separate portfolios, one for each event date. In the first column the days are numbered according to the event time where day zero is the day of announcement. Columns two and three show the average excess return of the portfolios day by day with their respective t-statistic. Columns four and five show the cumulative average excess return, starting cumulating at date 0, with respective t-statistic. Returns are expressed in percentage terms. All t-statistics are asymptotically normally distributed with mean zero and standard deviation one.

DAY	AVERAGE EXCESS RETURN	T-STATISTIC	CUMULATIVE EXCESS RETURN	T-STATISTIC
-10	0.4098	1.0585	-	-
-9	0.4725	1.1979	-	-
-8	0.3339	0.8562	-	-
-7	0.1899	0.4385	-	-
-6	0.5019	1.2881	-	-
-5	0.3915	0.9981	-	-
-4	0.1861	0.4496	-	-
-3	-0.1924	-0.6729	-	-
-2	0.3460	0.8646	-	-
-1	0.0843	0.1791	-	-
0	0.1532	0.3665	0.1532	0.3665
1	1.0203	2.6689	1.1734	2.1393
2	-0.0835	-0.2916	1.0899	1.5730
3	-0.3323	-0.9450	0.7576	0.8896
4	0.1236	0.2631	0.8813	0.9095
5	0.2398	0.5815	1.1211	1.0624
6	0.0568	0.0745	1.1779	1.0086
7	-0.5156	-1.4202	0.6622	0.4524
8	0.0108	-0.0075	0.6730	0.4229
9	0.2355	0.5959	0.9085	0.5826
10	-0.6070	-1.6738	0.3015	0.0666

Table 5, column four, presents cumulative excess returns from day 0 and onwards. Corresponding t-statistics are presented in column five. There is no evidence of a price reversal during the eleven-day period included in the table. This is also true for the rest of the event period following the announcement

date, even though this is not shown in the table. Therefore, hypothesis (ii), stating that there is no reversed price effect, cannot be rejected at a conventional significance level.

Introduction effect

The study of the introduction effect is based on data from all Nordic markets. The results from the analysis of the return effect around the introduction date

Table 6 Average and cumulative return residuals, and test statistics, around option introduction
The table shows 21 out of 61 daily excess returns and cumulative excess returns in the event window, defined to be 30 days before and after the listing day of an option. To calculate excess returns, a one-factor market model is used to describe normal returns, which are then subtracted from realised the returns. The estimated parameters in the market model are adjusted for asynchronous trading using the Fowler-Rorke [1983] methodology to calculate betas. Fifty-eight stocks from all Nordic markets (Denmark, Finland, Norway, and Sweden) are used and are grouped into 37 separate portfolios, one for each event date. In the first column the days are numbered according to the event time where day zero is the day of announcement. Columns two and three show the average excess returns of the portfolios day by day with their respective t-statistic. Columns four and five show the cumulative average excess returns, starting cumulating at date –4, with their respective t-statistic. Columns six and seven show the cumulative average excess returns, starting cumulating at date –7, with their respective t-statistic. The returns are expressed in percentage terms. All t-statistics are asymptotically normally distributed with mean zero and standard deviation one.

DAY	AVERAGE EXCESS RETURN	T-STATISTIC	CUMULATIVE EXCESS RETURN	T-STATISTIC	CUMULATIVE EXCESS RETURN	T-STATISTIC
-10	0.5123	1.5148	-	-	-	-
-9	0.0863	0.2181	-	-	-	-
-8	-0.2727	-1.0146	-	-	-	-
-7	0.5315	1.4455	-	-	0.5315	1.4455
-6	0.6547	1.9284	-	-	1.1862	2.3775
-5	0.3553	1.0210	-	-	1.5415	2.5198
-4	0.8909	2.6051	0.8909	2.6051	2.4324	3.4644
-3	-0.2850	-0.9998	0.6059	1.1311	2.1474	2.6483
-2	0.2950	0.8078	0.9009	1.3841	2.4424	2.7338
-1	0.2637	0.7238	1.1646	1.5526	2.7061	2.7893
0	-0.2750	-0.8722	0.8896	0.9991	2.4311	2.2986
1	-0.1236	-0.4013	0.7660	0.7411	2.3075	2.0212
2	0.1802	0.4731	0.9462	0.8595	2.4877	2.0579
3	0.4809	1.4102	1.4270	1.2877	2.9686	2.3669
4	-0.2738	-0.8850	1.1533	0.9236	2.6948	2.0134
5	-0.0681	-0.2308	1.0852	0.8028	2.6267	1.8670
6	0.1862	0.5244	1.2714	0.9158	2.8129	1.9278
7	-0.2517	-0.8059	1.0196	0.6503	2.5612	1.6585
8	0.3243	0.9369	1.3440	0.8723	2.8855	1.8239
9	-0.3090	-0.9613	1.0350	0.5919	2.5765	1.5428
10	-0.0712	-0.2475	0.9638	0.5089	2.5053	1.4392

are presented in Table 6.[31] No immediate effect on the stock returns at the introduction date is found: the excess return cannot be distinguished from zero. This is true even if the returns from day 0 and +1 are cumulated and jointly tested. Therefore, hypothesis (iii) cannot be rejected. As a consequence, hypothesis (iv) is not of current interest.

A reason for an effect around the introduction day could be the inventory build-up by market makers for hedging purposes. More detailed information about the introduction date is provided in Table 7. This is done in order to see if the market participants are building inventories up to one week before the introduction. It is tested whether the cumulated excess returns over the trading days 0 to 1, -1 to 1, -2 to 1, and so on up to -5 to 1, differ significantly from zero.[32] At no interval can any effect be found.

Table 7 Tests of cumulative excess returns five days before option listing to one day after option listing

CUMULATING DAYS	CUMULATIVE EXCESS RETURN	T-STATISTIC
-5 – +1	1.1214	1.0611
-4 – +1	0.7660	0.7411
-3 – +1	-0.1248	-0.3301
-2 – +1	0.1601	0.1224
-1 – +1	-0.1349	-0.3179
0 – +1	-0.3986	-0.8931

In spite of the statement above, there is a significant price effect at date -4 amounting to 0.9 percent. This could indicate the existence of a positive price effect caused by market makers building inventories of the share to hedge their future option positions. In that case the price effect should be temporary. But the effect is permanent; there are no price reversals, as can be seen from column five in Table 6. This statement holds for the whole 30-day period following the introduction. Considering that about 50 percent of the announcements occur seven to four days before the introduction date, it is possible that the announcement effect shows up as a positive excess return over the days -7 to -4. This argument is in line with the finding that there is no price reversal after the introduction date, and the significant cumulative effect during the days -7 to -4, found in column 6 and 7.

[31] In Table 6 the results from 21 days in the event window are presented. During the 40 days not displayed in the table, there is only one significant excess return.

[32] Other intervals were also tested, with no interesting results.

Additional tests are made to disclose any possible patterns in the excess returns. Cumulative abnormal returns over days -10 to +2 are plotted against the calendar time, to see if there exists a learning process among the market participants. The hypothesis is that CARs could decrease over time as traders learn about the positive return effect. However, no results are found to support this idea. Further, both the total risk and the systematic risk prior to the introduction are plotted against, and regressed on the excess returns. This is done in order to test if there is a difference in the abnormal returns depending on whether the stocks are of a high-risk or low-risk type prior to the introduction. Again, no statistically significant results were obtained.

Even though this study spans over a fairly long period of time, and the sample contains firms of variable size and age, the results cannot verify those of Sorescu (2000) and Mayhew and Mihov (1999). The reason could be that there is no time effect in the Nordic data, or that the short selling restrictions are not as severe in the Nordic markets.

In summary, the combined results from Table 5 and Table 6 indicate that there is a positive price effect on the underlying securities of the option introduction associated with the announcement date, but not with the introduction date. The cumulative excess return over the announcement day and the day after that is significantly positive, amounting to about one percent. The figures in column five, Table 5, also show that the price effect is permanent. The Nordic stock markets, therefore, behave fairly efficiently, without anomalies or delayed effects.

Selection bias or large firm effect

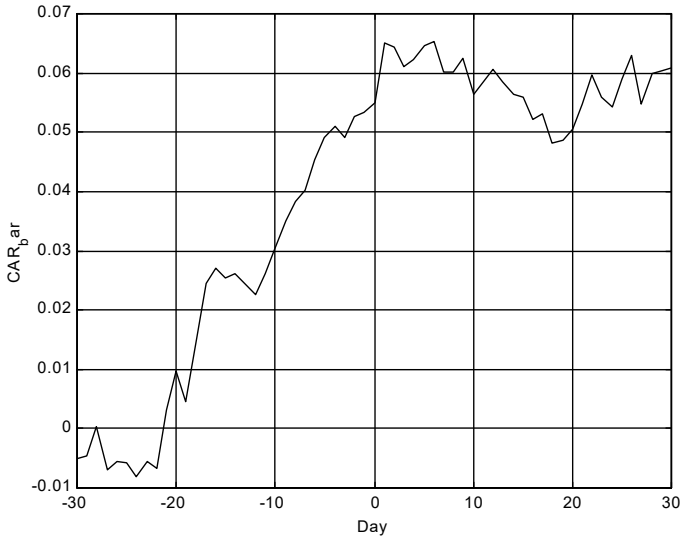
Figure 3 shows a distressing effect. There is a persistent price increase continuing during the entire first half of the event window. This finding can have three explanations.

Information could leak to the market participants prior to the actual announcement made by the respective stock exchange. This would lead to increasing prices if the information is considered as good news, and the information would be incorporated in the prices prior to the announcement day.

Furthermore, the significant price increase prior to the event date could be a result of the fact that mainly large enterprises are selected for option trading. These large firms have for a long time done relatively well compared to the rest of the stock market. In an attempt to control for such a large firm effect, a large firm return-index was used instead of the market index. This did not alter

any of the results presented above. If anything, the results were confirmed on a higher level of significance.

Figure 3 Cumulative return residuals around option introduction announcement



The early price increase could also be due to the special selection criteria used by the exchange when deciding which stocks to base new option listings on (see also the discussion after Table 4). To be able to set prices on derivative products, the underlying securities must be fairly liquid. This means that large, profitable growth firms, which are heavily traded, will be of greatest interest to use as an underlying security. New listings will therefore follow only if the stock has reached a certain level of volume, size, and liquidity.[33] Before a security reaches this threshold for being listed, it is probable that the stock is a 'winner' in relation to the rest of the market. Just subtracting each stock return series by the market return for a few years prior to the listing shows that in general the stocks in the sample outperform the market. This speaks in favour of a strong increase in the cumulative excess returns that can be seen prior to

[33] Mayhew and Mihov (1999) show that a firm's size, volume, and volatility are positively related to the probability of having options on its stock listed. Thereby a potential selection bias is introduced. Forming control samples of stocks that were eligible, but not selected for an option introduction, they re-examine some of the option listing effects in the literature. The effects still persist after this selection bias has been taken into consideration.

the event dates. Therefore, the outcome could be explained as a selection bias phenomenon.

4.4.2 Risk effect

Total risk

The results presented in this section originate from the examination of volatility in the underlying stocks at the introduction date only. The returns used to estimate portfolio variances are largely the same as for volatility measures around the announcement date and the introduction date. Twenty-one consecutive trading days are used in measuring volatility, and the median number of the trading days between announcement and introduction is five. Therefore, the results are virtually the same, independently of which of the two possible event dates are used. Even though the previous section indicates that the return effect is more associated with the announcement day, the listing day has been used as the defined event. It enables the use of option introductions from all Nordic markets, i.e. to enlarge the sample from 22 to 31 portfolios.

In Table 8, column two, twenty months of average excess standard deviations are presented. Excess standard deviations are expressed on a yearly basis. Cumulative excess standard deviations are calculated by adding the monthly deviations over time, and these values are used in the tests displayed in column five and seven. However, the cumulative excess standard deviations have no economical interpretation, but give some guidance to where the results are heading. The event occurs the first day in month one. The outcome of the ten months prior to the event month indicates how well the model works. As long as the model has some predictive power, there should be no significant excess standard deviation during the ten months prior to the introduction. As seen in Table 8, column three, none of the first ten months exhibit any significant excess volatility at a five-percent significance level. Neither shows the cumulated excess standard deviation over the ten-month period prior to the announcement any significant abnormal volatility. The t-statistics are presented in column five. During the following ten-month period after the introduction, six months (month 1 through 5, and 10) exhibit significant abnormal volatility. However, during the months with a significant decrease in standard deviation, the reduction in standard deviation lies between six and seven percent in the respective months. The figures from the whole period of ten consecutive months show a reduction in volatility. This makes it interesting to test whether the cumulative effect is significant. In column six and seven,

the cumulative excess standard deviations and their respective t-statistics for the ten months after the introduction date are presented. The cumulative effect shows a significant reduction in volatility after the introduction.

It is hard to give the numbers in column four and six a sound economic interpretation, since the standard deviations do not sum up to a meaningful number. In spite of the problems with interpreting the numbers, the tests are still valid since the residuals are normally distributed by assumption. The results attained when implementing the model that utilises the variances

Table 8 Average and cumulative volatility residuals, and test statistics, around option listing

The table shows excess standard deviations and cumulative excess standard deviations in the event window, defined to be ten months before and ten after the announcement day of an option introduction. The day of listing is included as the first day in the first month in event time following the introduction. To calculate excess volatility, a one-factor market model is used to describe normal volatility, which is then subtracted from the realised volatility. Monthly standard deviations, estimated over 21 consecutive trading days, are used as a volatility measure. Forty-eight stocks from all Nordic markets are used and are grouped into 31 separate portfolios, one for each event date. In the first column the months are numbered in event time where month one is the month including the listing day. Columns two and three show the average excess standard deviations of the portfolios month by month with their respective t-statistic. The standard deviations are expressed on a yearly basis. Columns four and five show the cumulative average excess standard deviations starting cumulating at month –9, with their respective t-statistic. Columns six and seven show the cumulative average excess standard deviations starting cumulating at month 1, with their respective t-statistic. All t-statistics are asymptotically normally distributed with mean zero and standard deviation one.

MONTH	AVERAGE EXCESS STD	T-STATISTIC	CUMULATIVE EXCESS STD	T-STATISTIC FROM MONTH –9 TO 10	CUMULATIVE EXCESS STD	T-STATISTIC FROM MONTH 1 TO 10
-9	-0.0049	-0.2122	-0.0049	-0.2122	-	-
-8	0.0240	0.9778	0.0191	0.5094	-	-
-7	0.0269	1.0608	0.0460	0.9250	-	-
-6	0.0350	1.4116	0.0809	1.3460	-	-
-5	-0.0017	-0.0666	0.0793	1.1331	-	-
-4	-0.0263	-1.0613	0.0529	0.6706	-	-
-3	-0.0455	-1.8358	0.0075	0.0856	-	-
-2	-0.0417	-1.6833	-0.0342	-0.3593	-	-
-1	-0.0220	-0.8839	-0.0562	-0.5459	-	-
0	-0.0193	-0.7780	-0.0755	-0.6850	-	-
1	-0.0587	-2.3684	-0.1342	-1.1430	-0.0587	-2.3684
2	-0.0655	-2.6321	-0.1997	-1.6075	-0.1242	-3.1387
3	-0.0589	-2.3738	-0.2586	-1.9737	-0.1830	-3.5423
4	-0.0664	-2.6738	-0.3249	-2.3567	-0.2494	-3.9999
5	-0.0663	-2.6370	-0.3913	-2.7079	-0.3157	-4.3874
6	-0.0406	-1.6052	-0.4318	-2.8575	-0.3563	-4.3893
7	-0.0349	-1.3886	-0.4668	-2.9603	-0.3912	-4.3612
8	-0.0476	-1.9227	-0.5144	-3.1364	-0.4389	-4.4947
9	-0.0309	-1.2409	-0.5453	-3.2063	-0.4698	-4.4663
10	-0.0663	-2.6473	-0.6116	-3.4831	-0.5361	-4.7790

instead of the standard deviation in equation (3), it is possible to get an idea of what an interpretable number could be for the reduction in standard deviation over the ten-month period after the introduction. By assumption there are no autocorrelations in the residual variances. Therefore, it is possible to cumulate the monthly residual variances over the period. Cumulating and taking the square root of the excess variance over the total ten-month period results in a number that can be interpreted as the cumulative reduction in standard deviation over the ten-month period. The result is a reduction of the standard deviation by 21.9 percent on a yearly basis, i.e. if the standard deviation were 40 percent before the announcement, it would be 31 percent one year later.

Thus, as total risk has changed, hypothesis (v) is rejected.

To see if the volatility effect has changed over time, the time of introduction is regressed upon the cumulative excess volatility for each stock. No significant time pattern is found, so the results of Mayhew and Mihov (1999) cannot be verified. An explanation might be that the Nordic exchanges have not yet exhausted the obvious candidates for listing, and are therefore still listing options in response to the permanent characteristics of the stocks, rather than to changes in market conditions, such as anticipated high volatility.

Idiosyncratic Risk

Variance ratios are used to test for a change in the idiosyncratic risk in connection with an option introduction. The total risk is also studied at the same time, using the same methodology, enabling a comparison between the different types of risks. The results are therefore presented together in this section.

As can be seen from Table 9, the two average SVRs are less than one (0.983 and 0.976), indicating that both the measured residual risk and the return volatility decline after the options have been introduced. Because the expectation of a ratio in general is greater than the ratio of expectations due to Jensen's inequality, it is likely that the median ratio is more informative. For the ten-month period considered, the median ratio is 0.909 and 0.843 respectively, indicating that the total volatility is reduced by almost 16%, while the firm specific volatility is reduced by 9 %. Testing the median to be different from one results in p-values in the order of 11%.

Due to the high p-value, the hypothesis (vi) cannot be rejected using variance ratios as measurement. The lack of significance when using variance ratios could, however, be explained by the low-powered test methodology. Support

Table 9 Variance ratios and standardised variance ratios for idiosyncratic and total risk around option introduction

The table shows variance ratios (VR) and standardised variance ratios (SVR) for 58 firms with optioned stocks. Market model residuals estimated with ten months of daily returns before and after the listing date are used to estimate the idiosyncratic risk. The residuals are used to calculate variances before and after the listing. Ten months of daily returns are used to estimate the stock return variance before and after the listing date. Standardised variance ratios are calculated by dividing each period's variance by its corresponding market variance. The standardisation adjusts for contemporaneous shifts in market volatility.

	IDIOSYNCRATIC RISK		TOTAL RISK	
	VR	SVR	VR	SVR
Mean	1.188	0.9835	1.193	0.976
Median	1.008	0.909	1.007	0.843
Proportion of firms with declining volatility	0.50	0.55	0.50	0.57
No. of VR significantly greater than one	20	12	20	12
No. of VR significantly less than one	17	26	17	26
Wilcoxon Test p-value for H0: Median = 1	0.423	0.113	0.394	0.112

for this statement can be found when comparing the results from the previous section studying the effect on the total risk. As is shown there, the effect is strongly significant, but when using variance ratios, the total risk effect is insignificant. Nabar and Park (1994) also point out the lack of power when using variance ratios. Even though the results are not statistically significant at conventional significance levels, it seems that more than half of the reduction of the total risk can be explained by a decline in the firm specific risk.

Systematic Risk

In the light of the significant decrease in the total risk, and considering that only half of it is explained by a reduction in the idiosyncratic risk, it could be expected that also the systematic risk would be influenced by the introduction of options. The analysis of the data has not supported this expectation. Estimating equation (9), 30 stocks out of 58 showed a reduction in beta. Six of these stocks showed significant shifts. Twenty-eight stocks showed an increase in beta after the option listing. Four of these were significant shifts. The shift coefficients were also plotted against calendar time. The coefficients were evenly distributed around zero with no time trend to be detected. Thus, the hypothesis (vii), presuming no change in the systematic risk, cannot be rejected.

This result differs from that of Alkebäck and Hagelin (1998), who find a significant decline in beta in their sample of Swedish optioned stocks. This

difference may be explained by a difference in the methodology used, and by the fact that they use average bid-ask spreads instead of transaction prices.

To conclude from the results in this section, the total risk in the underlying stocks are reduced on an average by 21.9 percent during the ten-month period after the introduction of options. Six out of ten individual months show a significant reduction in volatility, and the downward trend over the whole ten-month period is clear and significant. Although not significant, part of the reduction of the total risk can be attributed to the reduction in the idiosyncratic risk. No evidence could be found in support of the possibility that option listing effects the systematic risk of the underlying stocks. These findings are in accordance with findings in other studies. The results support the idea that introducing options enhance people's investment opportunities in a risk-reducing and market-stabilising way.

Table 10 Stability of beta around option introduction
The table shows the results from running 58 separate regressions for each firm of optioned stocks. The regression model used is the one described in equation (11). 361 days of returns are used in the estimation. The dummy variable in the model takes the value one in the periods following the option listing and zero otherwise. The table shows the shift coefficient γ_i and the number of shifts in beta, with their respective shift direction.

Average γ_i-value	0.0175	t-Statistic	0.22
No. of negative shifts	30	No. of sign. Neg. shifts	6
No. of positive shifts	28	No. of sign. Pos. shifts	4

4.5 Conclusions

In the Nordic countries, the introduction of standardised options with stocks as underlying securities has reached a volume, and has covered a time span long enough to generate data for a statistical analysis of the effects of option trading.

The results of this investigation are mostly in accordance with the outcome of studies based on data from other countries, mainly the USA.

The introduction of options has proved to render the underlying stocks a significant price increase, and a persistent excess return compared to an index indicating normal return. The positive effect is strong and similar in magnitude to those in studies based on data from other countries. Contrary to the experiences from other studies, however, the observed increase in return seems to be associated with the date of announcement of the option program, rather than the date of introduction. Further, there is no evidence of a trend in the size of the price effect, as found in recent work based on option introductions made in the US. The findings in this study are therefore in harmony with the market

efficiency hypothesis and the expectations that prices should be promptly adjusted when additional information reaches the market participants.

The positive price effect could be explained by a change in the risk of the underlying stock. An increased systematic risk or an increased idiosyncratic risk can lead to a price increase, assuming that the Capital Asset Pricing Model (CAPM) holds. As the results show, no statistically significant support can be found for this argument. It can also be argued that options expand the opportunity set of investors and promote risk reallocation, which can be beneficial to market participants. To the degree that the investors experience a better control of the financial risk when options are introduced, the required yield can be reduced.

The impact on the total risk is also favourable, and in line with findings in other studies. No influence on the systematic risk could be verified. The volatility in the underlying stocks is found to decrease continuously for ten months after the introduction of the option program. Further, there is no evidence of a trend in the size of the volatility effect, as found in recent US studies. These results support the notions that derivatives widen the investment choices of the market participants, decrease risks, and provide improved hedging opportunities.

The reduced total risk could be explained by a reduction in the systematic and/or idiosyncratic risk. However, the last mentioned two types of risks have not significantly changed. One reason may be the power of the methodology used, and given the amount of data. It is also possible that the total risk will shift without a change in the systematic risk, since an introduction of options should not affect the balance sheet of a company. In this case the different risk levels can be attributed to a change in the idiosyncratic risk, although this has not been possible to verify at conventional significance levels.

In all, this study supports the idea that option introductions make markets more efficient. Nothing in the analysis gives any indication that derivative trading should contribute to financial unrest. On the contrary, option programs seem to add increased stability to the market.

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4.7 Appendix A

To investigate the price effect of an option introduction, an event study is undertaken. When calculating the abnormal returns of a security, the normal return over the event window is subtracted from the actual ex-post return. A modified market model implementing Fowler-Rorke (1983) betas, which adjusts for non-synchronous trading, is used to model the normal returns.[34] It is assumed that the error term in the market model is normally distributed.

$$\hat{\varepsilon}_i^* = R_i^* - \hat{\alpha}_i \iota - \hat{\beta}_i R_m^* \quad \text{(A1)}$$

$\hat{\varepsilon}_i^*$ Abnormal return

R_i^* Vector of daily stock returns in the event window

R_m^* Vector of daily market returns in the event window

ι Vector of ones

$\hat{\alpha}_i^*$ Intercept coefficient estimated in the estimation window

$\hat{\beta}_i^*$ Regression coefficient estimated in the estimation window

The parameters in the market model are estimated on data in a period of 150 days after the event window (see Figure 1). To test for significant abnormal returns on individual stocks when options are introduced, the abnormal returns are averaged across stocks:

$$\overline{\varepsilon}^* = \frac{1}{N}\sum_{i=1}^{N} \hat{\varepsilon}_i^*. \quad \text{(A2)}$$

Because of the uncertainty about the event date, it is sometimes interesting to test the abnormal return earned over a period of time. For this exercise the abnormal return is added over the considered time period. Define $\overline{CAR}(\tau_1, \tau_2)$ to denote the cumulative average abnormal return from τ_1 to τ_2, where τ_1 and

[34] Fowler-Rorke betas are calculated by running the regression below:

$$R_t = \alpha + \beta^{--}Rm_{t-2} + \beta^{-}Rm_{t-1} + \beta^{0}Rm_t + \beta^{+}Rm_{t+1} + \beta^{++}Rm_{t+2}$$

The stock's beta is then a weighted sum of the estimated regression parameters, as follows:

$$plim\hat{\beta} = \frac{1+\rho_1+\rho_2}{1+2\rho_1+2\rho_2}\beta^{--} + \frac{1+2\rho_1+\rho_2}{1+2\rho_1+2\rho_2}\beta^{-} + \beta^{0} + \frac{1+2\rho_1+\rho_2}{1+2\rho_1+2\rho_2}\beta^{+} + \frac{1+\rho_1+\rho_2}{1+2\rho_1+2\rho_2}\beta^{++}$$

The superscripts ++, +, 0, -, and -- indicate that each time series is shifted two days' lead, one day's lead, no lag, one day's lag, and two days' lag. ρ_1 and ρ_2 are the first and second order autocorrelation coefficients. This way of estimating beta is consistent with the methodology proposed by Scholes-Williams (1977).

τ_2 are two dates within the event window. For the cumulative average abnormal return we have:

$$\overline{CAR}(\tau_1, \tau_2) = \sum_{t=\tau_1}^{\tau_2} \overline{\varepsilon}_t^*. \quad \text{(A3)}$$

The average cumulative abnormal returns are normally distributed with an expected abnormal return of zero. This can be used to draw an inference about the abnormal returns. To derive a test statistic that can be used to test for the significance of the average cumulative abnormal return, the variance of the average cumulative abnormal return in equation (A3) is needed. Denote the covariance matrix of the estimated abnormal return by $V_i = E\left[\hat{\varepsilon}_i^* \varepsilon_i^{*\prime} | X_i^*\right]$. Let γ be a (61 x 1) vector with ones in the position of the days corresponding to the interval τ_1 to τ_2 and zeros elsewhere. Aggregating the covariance matrices V_i across stocks results in a covariance matrix for the average abnormal return vector $\overline{\varepsilon}^*$, i.e.

$$Var\left(\overline{\varepsilon}^*\right) = V = \frac{1}{N^2} \sum_{i=1}^{N} V_i. \quad \text{(A4)}$$

By using the gamma vector to aggregate over time the variance of the average cumulative abnormal return can be calculated as

$$Var\left[\overline{CAR}(\tau_1, \tau_2)\right] = \overline{\sigma}^2(\tau_1, \tau_2) = \gamma' V \gamma. \quad \text{(A5)}$$

The hypothesis that the abnormal return is equal to zero can be tested by using the test statistic

$$J = \frac{\overline{CAR}(\tau_1, \tau_2)}{\sqrt{\hat{\overline{\sigma}}^2(\tau_1, \tau_2)}} \underset{\sim}{a} N(0,1) \quad \text{(A6)}$$

where a sample estimate of $\overline{\sigma}^2(\tau_1, \tau_2)$ is used.

4.8 Appendix B

The following is the derivation of the estimation procedure for the different volatility models proposed in section two, equation (3). The standard deviation will be used throughout the derivation, but the derivation is the same independently of the volatility measure. Just change σ to any of the other two measures. The notation used in the derivation follows Nabar and Park (1994), and Judge et al. (1980). The derivation is carried out for one single security.

Let

$$Y = \begin{bmatrix} \sigma_{i,1} \\ \vdots \\ \sigma_{i,T} \end{bmatrix}$$

be the vector of independent values during the estimation period, and

$$X = \begin{bmatrix} 1 & \sigma_{m,1} \\ \vdots & \vdots \\ 1 & \sigma_{m,T} \end{bmatrix}$$

be the matrix of dependent variables in the estimation window. σ_{it} is the standard deviation of stock i in month t and σ_{mt} is the standard deviation of the market index in month t. Also, let

$$\varepsilon = \begin{bmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_T \end{bmatrix} \tag{B1}$$

be the disturbance vector, which is assumed to be normally distributed. Recall that the market model for standard deviations is

$$\sigma_{it} = a_i + b_i\sigma_{mt} + e_{it}. \tag{B2}$$

This can be expressed as a regression system on the form

$$Y = X\beta + \varepsilon, \tag{B3}$$

where $\beta = [a \quad b]'$ is the vector of parameters. In this case assume that the residuals follow an AR(1) process, i.e.

$$\epsilon_\tau \rho \varepsilon_{\tau-1} + \nu_\tau \Longrightarrow \sigma_\varepsilon^2 = \frac{\varepsilon_\nu^2}{1-\rho^2}. \tag{B4}$$

Let $\hat{\varepsilon}$ be the OLS residual and estimate $\rho = corr(\hat{\varepsilon}_t, \hat{\varepsilon}_{t-1})$ by

$$\hat{\rho} = \frac{\sum_{t=2}^{T} \hat{\varepsilon}_t \hat{\varepsilon}_{t-1}}{\sum_{t=1}^{T} \hat{\varepsilon}_t^2}. \tag{B5}$$

Estimate the variance of the residual in the AR(1) process by

$$\hat{\sigma}_v^2 = \frac{(Y - X\beta)' \hat{P}' \hat{P} (Y - X\beta)}{T - K}, \tag{B6}$$

where $\hat{P}$ is the estimated transformation matrix. The estimation is done by using $\hat{\rho}$. The transformation matrix is described next. If

$$E(\varepsilon\varepsilon') = \sigma_\varepsilon^2 \Omega = \frac{\sigma_v^2}{1-\rho^2} \Omega = \sigma_v^2 \Psi \tag{B7}$$

let

$$P'P = \Psi^{-1} \tag{B8}$$

where P is a transformation matrix. Using ρ it looks like

$$P = \begin{bmatrix} \sqrt{1-\rho} & 0 & 0 & \cdots & 0 & 0 \\ -\rho & 1 & 0 & \cdots & 0 & 0 \\ 0 & -\rho & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 1 & 0 \\ 0 & 0 & 0 & \cdots & -\rho & 1 \end{bmatrix}. \tag{B9}$$

From the definition of P, it follows that

$$\Psi = \frac{1}{1-\rho^2} \begin{bmatrix} 1 & \rho & \cdots & \rho^{T-2} & \rho^{T-1} \\ \rho & 1 & \cdots & \rho^{T-3} & \rho^{T-2} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \rho^{T-2} & \rho^{T-3} & \cdots & 1 & \rho \\ \rho^{T-1} & \rho^{T-3} & \cdots & \rho & 1 \end{bmatrix} \tag{B10}$$

and

$$\Psi^{-1} = \begin{bmatrix} 1 & -\rho & 0 & \cdots & 0 \\ -\rho & 1+\rho^2 & \ddots & \ddots & \vdots \\ 0 & \ddots & \ddots & \ddots & 0 \\ \vdots & \ddots & \ddots & 1+\rho^2 & -\rho \\ 0 & \cdots & 0 & -\rho & 1 \end{bmatrix}. \tag{B11}$$

Transform the data

$$\begin{aligned} PY &= PX\beta + P\varepsilon \\ &\Longrightarrow Y_* = X_*\beta + P\varepsilon \\ &\Longrightarrow \hat{\beta} = (X'\Omega^{-1}X)^{-1}(X'\Omega^{-1}Y) \\ &\Longrightarrow \hat{\varepsilon} = Y - X\hat{\beta} \end{aligned} \tag{B12}$$

Post estimation period residuals become

$$\begin{aligned} \hat{\varepsilon}^*_{T+1} &= y^*_{T+1} - \hat{\beta}' x^*_{T+1} - \rho\hat{\varepsilon}_T \\ \hat{\varepsilon}^*_{T+n} &= y^*_{T+n} - \hat{\beta}' x^*_{T+n} - \rho^n\hat{\varepsilon}_T \end{aligned} \tag{B13}$$

and result in a 1 by n vector

$$\varepsilon^* = Y^* - X^*\hat{\beta} - V'\Psi^{-1}\left(Y - X\hat{\beta}\right) = Y^* - X^*\hat{\beta}V'\Psi^{-1}\hat{\varepsilon}, \tag{B14}$$

where n is the number of months in the event window. Y^* and X^* are the dependent and independent variables in the event window, see Figure 2. The matrix V is described in what follows. To be able to draw an inference about the abnormal variances ε^*, the covariance matrix has to be derived. Let

$$E\left[\begin{pmatrix}\varepsilon \\ \varepsilon^*\end{pmatrix}(\varepsilon' \quad \varepsilon^{*\prime})\right] = \sigma_v^2\begin{bmatrix}\Psi & V \\ V & \Psi^*\end{bmatrix} = E\begin{bmatrix}\varepsilon\varepsilon' & \varepsilon\varepsilon^{*\prime} \\ \varepsilon^*\varepsilon' & \varepsilon^*\varepsilon^{*\prime}\end{bmatrix} \tag{B15}$$

then

$$V = \frac{1}{1-\rho^2}\begin{bmatrix} \rho^T & \rho^{T+1} & \cdots & \rho^{T+n-2} & \rho^{T+n-1} \\ \rho^{T-1} & \rho^T & \cdots & \rho^{T+n-3} & \rho^{T+n-2} \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ \rho^2 & \rho^3 & \cdots & \rho^n & \rho^{n+1} \\ \rho & \rho^2 & \cdots & \rho^{n-1} & \rho^n \end{bmatrix} \tag{B16}$$

and

$$\Psi^{*} = \frac{1}{1-\rho^{2}} \begin{bmatrix} 1 & \rho & \cdots & \rho^{n-2} & \rho^{n-1} \\ \rho & \ddots & & & \rho^{n-2} \\ \vdots & & \ddots & & \\ \rho^{n-2} & & & \ddots & \rho \\ \rho^{n-1} & \rho^{n-2} & \cdots & \rho & 1 \end{bmatrix}. \tag{B17}$$

The variance covariance matrix becomes

$$\begin{aligned} \Sigma &= E\left[\hat{\varepsilon}^{*}\hat{\varepsilon}^{*\prime} | \boldsymbol{X}^{*}, \Psi^{-1}, \boldsymbol{V}\right] = \\ &= \sigma_{v}^{2}\left[\boldsymbol{X}^{*}\boldsymbol{C}\boldsymbol{X}^{*\prime} + \Psi^{*} - \boldsymbol{V}^{\prime}(\Psi^{-1} - \Psi^{-1}\boldsymbol{X}\boldsymbol{C}\boldsymbol{X}^{\prime}\Psi^{-1})\boldsymbol{V} - \right. \\ &\left. -\boldsymbol{X}^{*}\boldsymbol{C}\boldsymbol{X}^{\prime}\Psi^{-1}\boldsymbol{V} - \boldsymbol{V}^{\prime}\Psi^{-1}\boldsymbol{X}\boldsymbol{C}\boldsymbol{X}^{*\prime}\right] \end{aligned} \tag{B18}$$

where

$$C = [X^{\prime}\Psi^{-1}X]^{-1}. \tag{B19}$$

4.9 Appendix C

Table C1a Shares of companies, announcement dates and listing dates used in the study.
The abbreviations stand for Options Mäklarna (OM), Oslo Stock Exchange (OSE), Copenhagen Stock Exchange (CSE), and Helsinki Stock Exchange (HSE). The price series were taken from either Scandinavian Information Exchange (SIX) or Datastream (DS).

COMPANY NAME	SYMBOL	EXCHANGE	DATABASE	LISTED	DELISTED	ANNOUNCED
ASTRA A BU	ASTR-AB.SE	OM	SIX	1985-06-12		1985-05-06
ATLAS COPCO A	ATCO-A.SE	OM	SIX	1985-06-12		1985-05-06
BOLIDEN A	BOLI-AB.SE	OM	SIX	1985-06-12	1987-12-16	1985-04-29
SCA B BU	SCA-BB.SE	OM	SIX	1985-06-12		1985-04-29
SKANDIA FR	SDIA.SE	OM	SIX	1985-06-12		1985-04-29
VOLVO B BU	VOLV-BB.SE	OM	SIX	1985-06-12		1985-04-29
ELECTROLUX B FR	ELUX-B.SE	OM	SIX	1986-02-10		1986-01-31
ERICSSON B FR	LME-B.SE	OM	SIX	1986-02-10		1986-01-31
PHARMACIA B	GPHA-BB.SE	OM	SIX	1986-07-21	1990-07-09	1986-07-17
SKF B FR	SKF-B.SE	OM	SIX	1986-07-21		1986-07-17
S-E-BANKEN A	SEB-A.SE	OM	SIX	1987-06-01		1987-05-21
ASEA A BU	ABB-AB.SE	OM	SIX	1988-04-11		1988-04-05
TRELLEBORG B BU	TREL-BB.SE	OM	SIX	1988-09-12		1988-09-08
SKANSKA B BU	SKA-BB.SE	OM	SIX	1989-02-06		1989-02-02
SAAB A	GSAA-AB.SE	OM	SIX	1989-03-23	1991-03-08	1989-03-21
SVENSKA HANDELSBANKEN	SHB-A.SE	OM	SIX	1989-03-23		1989-03-21
MUNKSJÖ A BU	GMUN-AB.SE	OM	SIX	1989-06-07	1991-01-22	1989-06-02
AVESTA BU	AVES-BU.SE	OM	SIX	1990-04-04		1990-03-28
BERGESEN	N:BEB(RI)	OSE	DS	1990-05-22		
HAFSLUND NYCOMED B	N:HNB(RI)	OSE	DS	1990-05-22	1990-12	
NORSK HYDRO	N:NHY(RI)	OSE	DS	1990-05-22		
SAGA PETROLEUM A	N:SAG(RI)	OSE	DS	1990-05-22		
DANISCO	N:DAOG(RI)	CSE	DS	1990-12-07		
DEN DANSKE BANK	N:CL@G(RI)	CSE	DS	1990-12-07		
NOVO NORDISK B	N:NI@G(RI)	CSE	DS	1990-12-07		

Table C1b Shares of companies, announcement dates and listing dates used in the study.
The abbreviations stand for Options Mäklarna (OM), Oslo Stock Exchange (OSE), Copenhagen Stock Exchange (CSE), and Helsinki Stock Exchange (HSE). The price series were taken from either Scandinavian Information Exchange (SIX) or Datastream (DS).

COMPANY NAME	SYMBOL	EXCHANGE	DATABASE	LISTED	DELISTED	ANNOUNCED
UNIDANMARK A	N:UNNDK(RI)	CSE	DS	1990-12-07		
HAFLUND NYCOMED A	N:HNA(RI)	OSE	DS	1991-12-20	1996-05	
INVESTOR B FR	INVE-B.SE	OM	SIX	1992-03-23		1992-03-12
CARLSBERG B	N:CQBG(RI)	CSE	DS	1993-01-07		
ISS B	N:IS@G(RI)	CSE	DS	1993-01-07		
KVAERNER A	N:KVI(RI)	OSE	DS	1993-04-29		
SANDVIK B FR	SAND-B.SE	OM	SIX	1993-05-28		1993-05-19
NORDSTRÖM & THULIN	N&T-B.SE	OM	SIX	1993-06-01		1993-05-25
STORA B FR	STOR-B.SE	OM	SIX	1993-06-04		1993-05-28
HUHTAMÄKI I	M:HUIF(RI)	HSE	DS	1993-10-01		
NOKIA A	M:NOKP(RI)	HSE	DS	1993-10-01		
POHJOLA B	M:POBR(RI)	HSE	DS	1993-10-01		
KINNEVIK B FR	KINV-B.SE	OM	SIX	1993-10-11		1993-10-07
ENSO R	M:EGR(RI)	HSE	DS	1994-01-17		
AKER A	N:AKE(RI)	OSE	DS	1994-01-31	1999-02	
MODO B	MODO-B.SE	OM	SIX	1994-03-08		1994-03-04
SSAB A	SSAB-A.SE	OM	SIX	1994-03-08		1994-03-04
OUTOKUMPU	M:OUTO(RI)	HSE	DS	1994-08-02		
HENNES & MAURITZ B	H&M-B.SE	OM	SIX	1995-05-17		1995-05-10
STADSHYPOTEK	SHYP-A.SE	OM	SIX	1995-06-16	1997-05-16	1995-06-09
AUTOLIV AB	ALAB.SE	OM	SIX	1995-09-19	1997-05-09	1995-09-14
OY NOKIA AB	NOKI-SDB.SE	OM	SIX	1996-06-27		1996-06-19
NORDBANKEN AB	NORB.SE	OM	SIX	1996-10-14		1996-10-07
ALLGON B	ALLG-B.SE	OM	SIX	1997-01-28		1997-01-20
ELKEM	N:ELK(RI)	OSE	DS	1997-02-14		1997-02-04
NORSKE SKOGINDUSTRIER	N:NSG(RI)	OSE	DS	1997-02-14		1997-02-04
DEN NORSKE BANK	N:DNB(RI)	OSE	DS	1997-04-10		1997-04-07
PGS	N:PGS(RI)	OSE	DS	1997-04-10		1997-04-07
NYCOMED A	N:NYC(RI)	OSE	DS	1997-05-15		

Table C1c Shares of companies, announcement dates and listing dates used in the study.
The abbreviations stand for Options Mäklarna (OM), Oslo Stock Exchange (OSE), Copenhagen Stock Exchange (CSE), and Helsinki Stock Exchange (HSE). The price series were taken from either Scandinavian Information Exchange (SIX) or Datastream (DS).

COMPANY NAME	SYMBOL	EXCHANGE	DATABASE	LISTED	DELISTED	ANNOUNCED
ORKLA A	N:ORK(RI)	OSE	DS	1998-04-20		1998-04-02
STOREBRAND	N:STB(RI)	OSE	DS	1998-04-20		1998-04-02
NCL HOLDING	N:NCL(RI)	OSE	DS	1998-08-28		1998-08-21
MERKANTILDATA	N:MED(RI)	OSE	DS	1998-11-20		1998-11-04

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